4.0 TECHNOLOGY EFFECTIVENESS

The following sections discuss the sample results and effectiveness of the GFT technology to treat PCB- and metal-contaminated sediments.

4.1 DEMONSTRATION BACKGROUND

This demonstration evaluated the effectiveness of the GFT process to treat PCB- and metal-contaminated sediment. The technology evaluation consisted of pre-treatment (and pre-dryer) sediment sampling; post-dryer sediment sampling and post-melter glass; and air, quench-water, and cooling-tower-water sampling during treatment.

Sediment used in this demonstration was obtained from the Lower Fox River during the 1999-2000 Sediment Management Unit (SMU) 56/57 pilot dredging project, which included hydraulic dredging, onshore dewatering, filter pressing, treatment with lime, and disposal of PCB-contaminated sediment. The sediment removal action was conducted adjacent to the Fort James Corporation facility in Green Bay, and dewatered sediment was disposed of at the Fort James Landfill, while all treated water was returned to the river. WDNR conducted oversight on the project with funding from the Fox River Group. The SMU 56/57 project goal was to generate information to assess the effectiveness and expense for large-scale sediment dredging and disposal of contaminated sediment from the Lower Fox River.

In general, the dredging project consisted of hydraulic dredging of a portion of the river bottom into two lined settling basins. After the solids settled out, they were pumped to plate-and-frame presses for mechanical dewatering. Lime was added, on an as-needed basis, to aid solidification, and the sediment was transported to the Fort James Landfill for disposal. Water was treated with sand filtration and activated carbon before it was discharged back into the Lower Fox River.

A portion of the sediment from the SMU 56/57 project was segregated for the purpose of the SITE evaluation of the GFT, an innovative sediment-treatment technology. On December 17, 1999, rather than loading all dredged-and-dewatered sediment into trucks for transport and disposal, a portion was loaded into four lined 20-cubic-yard roll-off boxes. The boxes were covered and transported to the Brown County Landfill in Green Bay, Wisconsin, where the sediment was temporarily stored until the GFT evaluation.

4.2 METHODOLOGY AND TECHNOLOGY IMPLEMENTATION

This section details activities conducted prior to and during the GFT demonstration. The evaluation was arranged to scientifically verify Minergy's claims and to assess the effectiveness of the GFT in meeting project objectives. Objectives form the basis for the evaluation and provide a measure by which performance of the technology can be measured. Elements of the experimental approach and the procedures involved, conducted during both the dryer and melter demonstrations, are presented in the following sections. Table 4-1 summarizes the events and dates of the demonstrations.

TABLE 4-1
SUPERFUND INNOVATIVE TECHNOLOGY EVALUATION DEMONSTRATION EVENTS

Event	Duration
Dryer Demonstration at Hazen Research, Golden, Colorado	January 23 through 25, 2001
Dredged-and-Dewatered Sediment Sampling from Roll-off Boxes at Minergy Facility, Winneconne, Wisconsin	April 24 and May 7, 2001
Dried Sediment Sampling from Supersacks after Drum Dryer at Minergy Facility, Winneconne, Wisconsin	June 4 and 5, 2001
GFT Melter Demonstration at Minergy Facility, Winneconne, Wisconsin	June 19 through 23, 2001 and August 14 through 17, 2001
Glass Samples Crushed at UW-Platteville, Platteville, Wisconsin	August 22 and 23, 2001

4.2.1 Pre-demonstration Activities

Before sediment could be fed into the melter, the moisture content needed to be reduced from a dewatered condition (50 percent) to a moisture content of 5 to 15 percent for optimal melter efficiency. Minergy researched available drying technologies and determined that an indirect heat disc or paddle dryer unit was the most appropriate drying technology for the GFT treatment process; however, no production-sized dryers of this type were available for use at the Minergy facility or elsewhere. Therefore, Minergy set up a bench-scale demonstration of a Holoflite® dryer at the Hazen facility in Golden, Colorado, to provide data on a unit similar to that intended for use by Minergy in the full -scale design.

4.2.1.1 Hazen Research Inc. Dryer Demonstration

Based on the dust carryover into the air and condensate streams, it was evident that the results were strongly influenced by the contamination in the dust and should be disregarded. The size of the bench-scale Holoflite® dryer also proved to be inadequate to achieve the evaluation objectives. Appendix C contains details of the Hazen Holoflite® dryer demonstration.

4.2.1.2 Drum Dryer

The dryer selected by Minergy to dry the bulk of the sediment to be used in the melter demonstration was not suitable for sampling and evaluation of its potential waste streams. Minergy had planned the dryer test to be a bench-scale demonstration only, using a portion of the sediment. The rest of the sediment stored in the roll-off boxes was to be dried using a different technology. The dredged-and-dewatered sediment was manually shoveled from the roll-off boxes into 55-gallon drums. The drums were placed, 12 at a time, into a drum oven, where they were heated for about 36 hours, until the sediment contained about 10 percent moisture. The drum oven was chosen, because it was electrically heated and could be set up for low-temperature drying, with minimal air circulation. Each dried, 12-drum batch was transferred to two supersacks, weighing about 1,000 pounds each. Thirty batches of sediment were dried in the drum oven, yielding 60 supersacks of dried sediment. Each supersack was numbered to designate from which roll-off box the sediment originated.

4.2.2 Glass Furnace Technology Melter Demonstration

The melter-demonstration evaluation was designed to collect six composite samples of the sediment entering the melter and six composite samples of glass aggregate product exiting the melter. These samples would provide the data necessary to evaluate the primary objectives. In addition, samples were collected from all waste streams of the melter, including air, quench-tank water, cooling-tower water, accumulated dust, and flux.

4.2.2.1 June 2001 Glass Furnace Technology Demonstration

Minergy initially began the GFT demonstration on June 19, 2001. The demonstration began with the melter warmup and introduction of sediment. Minergy began melting sediment segregated for the SITE

demonstration early on the morning of June 20, 2001. Sediment grab samples were collected at 15-minute intervals over a 6-hour period. Glass aggregate product samples were collected at 15-minute intervals over a 6-hour period. Glass-aggregate-product sampling began after completion of the 6-hour sediment feed sampling. The sampling protocol was arranged to account for the 6-hour residence time within the melter, so that sampled glass aggregate corresponded with sampled sediment.

The initial demonstration suffered problems associated with the flow of sediment feed and the effluent flow of the molten glass from the weir of the melter. The lack of fluidity of the molten glass caused many interruptions of the flow from the melter and forced adjustments to the sampling schedule. In cases where flow was interrupted for a significant period of time, sampling of the glass aggregate was suspended until flow was restored. Upon restoration of the molten glass flow, sampling resumed at shorter intervals to collect the required volume of glass aggregate within the 6-hour sampling period. These conditions persisted over the first 2 days of the melter demonstration.

On the third day of the demonstration, molten glass began leaking through the side of the melter at the forehearth and spilled onto the floor. The leak location was immediately doused with cold water, and project stakeholders decided to halt the demonstration due to the hazardous conditions resulting from the melter leak. The molten sediment was more corrosive to the originally selected refractory brick than previously predicted. The melter was rebuilt with an improved grade of refractory and the demonstration was re-scheduled.

4.2.2.2 August 2001 Glass Furnace Technology Demonstration

The melter demonstration restarted on August 13, 2001, with melter warming, sediment introduction, and sampling of the sediment, glass, and other waste streams from the melter operation. Less sediment was available for this demonstration as a result of the failed first attempt, so two sampling runs were conducted each day, rather than one. This schedule was necessary due to a shortened melter demonstration period.

The melter operated continuously throughout the August-demonstration period. Sediment and glass sampling began on August 14 and ended August 16, 2001. Molten glass continued to flow from the melter as long as sediment entered the melter. The sampling probe that was inserted into the flue to collect air samples was a source of intermittent problems caused by plugging with what was thought to be flux material. The material buildup resulted in the periodic interruption of air sampling so that the probe

could be cleaned. The interruption of flow lengthened the time needed to collect individual air samples; consequently, the air sampling team worked in shifts to cover the sampling 24 hours per day. Air sampling activities continued for 5 days and ended on August 17, 2001, while sediment and glass sampling was completed in 3 days.

All of the melter data presented in this ITER were generated during the August 2001 demonstration.

4.2.3 Sampling Program

To facilitate evaluation of the technology, a sampling program was designed to assess the GFT's capacity to meet the objectives outlined above. The sampling program was detailed in the quality assurance project plan (QAPP) (EPA 2001) before the demonstration was begun.

The roll-off boxes were delivered to Minergy's facility in Winneconne, Wisconsin, and thawed. A hand auger was used to collect sediment samples from randomly selected locations within the roll-off boxes. Those samples were composited by coning and quartering on a plastic sheet. Six composite sediment samples were collected from the roll-off boxes. The material in the roll-off boxes was subsequently processed in the drum dryer.

4.2.3.1 Drum Dryer

Because the SITE evaluation intended to use data collected from an indirect disc or paddle dryer, sampling of the drum dryer was not outlined in the QAPP. After the data from the bench-scale dryer were determined to be inadequate, it was decided to collect samples of the dredged-and-dewatered sediment entering the drum dryer and as well as the dried sediment exiting the drum dryer. No samples of air or condensate emitted by the dryer were sampled. The drum dryer was not configured to allow for sampling of the exhaust or condensate.

4.2.3.2 Glass Furnace Technology Melter

Sampling of the GFT melter was planned to obtain corresponding samples of sediment entering the melter, glass aggregate product exiting the melter, and quench water used to cool the molten glass. Air and other samples collected during the demonstration were not meant to parallel sediment and glass samples. Sediment and glass samples were collected as composite samples, to assess the uniformity, as well as potential contaminant losses, of the sediment feed and glass product. Composites consisted of 24 individual grab samples gathered every 15 minutes over a 6-hour period. Quench-water composite samples consisted of 12 grab samples collected over a 6-hour period.

Ancillary media samples, such as air, cooling tower discharge water, city water, and flux were not collected as composite samples. Forty air samples were collected to be analyzed for PCBs, dioxins and furans, semi-volatile organic compounds (SVOCs), metals, VOCs, and hydrogen chloride/chlorine. For the August 2001 demonstration, sediment and glass sampling was completed in 3 days, while air sampling required five 24-hour sampling days to collect the desired number of samples.

4.3 GFT DEMONSTRATION DATA

This section presents the results of data gathered for the drum dryer and GFT melter during the SITE demonstration. Sediment, glass, air, and water sampling results and operating data were used to evaluate the performance of the GFT in relation to evaluation objectives. Sampling results are shown in Tables 4-2 through 4-12. Significant figures used to report analytical data in the tables and text of this report reflect the same number of significant figures reported by the laboratories. All solids results are reported on a dry-weight basis.

4.3.1 Dryer

Data collected from the sampling of the dredged-and-dewatered sediment in the roll-off boxes and the dried sediment in the supersacks at the Minergy facility in Winneconne, Wisconsin, were used to calculate the Treatment Efficiency (TE) of the GFT. Results of the before and after dryer samples collected in Winneconne, Wisconsin, are detailed in the following sections. As mentioned in Section 4.2.1.1, results of the Holoflite® dryer sampling are detailed in Appendix C, but are not used in the evaluation of the GFT.

4.3.1.1 Dredged-and-Dewatered Sediment

To evaluate the GFT process as a whole, dredged-and-dewatered (wet) sediment samples were collected from the roll-off boxes.

Composite samples were analyzed for both the Wisconsin State Laboratory of Hygiene list of PCB congeners and total PCBs by EPA Method 680 (EPA 1985). The results of the analyses are presented in Table 4-2. Total PCB results were calculated by summing the concentration of homologs (series of PCBs where each successive member has one additional chlorine). Non-detect values were not used in this calculation. These concentrations ranged from 20.1 to 35.9 ppm.

4.3.1.2 Drum-Dried Sediment

Six composite samples were collected from the supersacks containing drum-dried sediment and were analyzed for both the Wisconsin State Laboratory of Hygiene list of PCB congeners and total PCBs by EPA Method 680 (EPA 1985). Total PCB results, calculated by summing the concentration of PCB homologs, are reported in Table 4-3. The results range from 20.5 to 25.0 ppm.

TABLE 4-2
DREDGED-AND-DEWATERED SEDIMENT RESULTS

Analyte	Sample Identification					
PCBs (Method 680) (ng/g)	Rolloff #3			Rolloff #4		
	Lift 1	Lift 2	Lift 3	Lift 1	Lift 2	Lift 3
(1)-MoCB	260	279	190	275	<341	277
(4,10)-DiCB	1,050	1,010	642	842	879	721
(9,7)-DiCB	195	198	113	164	165	132
(6)-DiCB	1,630	1,680	942	1,390	1,350	1,090
(5,8)-DiCB	2,010	2,040	1,150	1,740	1,660	1,350
(19)-TriCB	302	292	172	252	248	201
(18)TriCB	2,700	2,750	1,460	2,210	2,090	1,690
(17)-TriCB	1,500	1,470	823	1,260	1,210	988
(27,24)-TriCB	326	321	184	278	270	220
(16,32)-TriCB	1,850	1,860	1,030	1,570	1,490	1,220
(29)-TriCB	<4.39	<4.67	<3.59	5.25	<4.61	<4.20
(26,25)-TriCB	2,820	2,890	1,570	2,440	2,280	1,880
28,(31)-TriCB	7,350	7,320	4,060	6,320	5,920	4,860
(21,33,20)-TriCB	825	793	459	721	683	552
(22)-TriCB	851	828	484	752	718	578
(37)-TriCB	554	508	316	500	469	381
(53)-TeCB	274	278	151	232	221	182
(45)-TeCB	271	280	154	234	226	185
(46)-TeCB	104	108	58.6	90.4	84.9	70.6
(43),52-TeCB	1,540	1,550	860	1,330	1,260	1,040
(49)-TeCB	1,190	1,190	666	1,030	984	820
(47,48,75)-TeCB	646	625	362	557	539	446
(44)-TeCB	1,070	1,140	603	1,100	900	746
(59,42)-TeCB	588	592	341	354	485	423
(41,71,72)-TeCB	628	636	358	554	531	440
(64,68)-TeCB	879	870	499	774	745	613
(40)-TeCB	214	224	124	190	183	150
(63)-TeCB	108	105	61.6	96.0	93.6	77.7
(74)-TeCB	483	463	276	434	417	340
(70)-TeCB	637	578	357	566	537	442
(66,80)-TeCB	654	616	378	605	573	460
(56,60)-TeCB	517	498	300	470	453	364
(77)-TeCB	148	141	85.8	135	131	111
(91)-PeCB	55.7	54.3	32.4	49.8	48.0	39.9
(84)-PeCB	83.1	86.8	49.9	75	71.2	59.9
(101,113)-PeCB	150	145	91.3	138	131	104
(99)-PeCB	94.0	90	56.5	86.1	82.4	68.2
(119,112)-PeCB	14.6	13.9	9.00	14.1	13.4	10.7
(86,97,125)-PeCB	61.2	59.7	36.9	55.4	53.0	44.0
(87,111,115)-Pecb	72.6	72.9	44.8	68.0	63.7	53.1
(85)-PeCB	45.7	45.4	27.3	41.4	40.5	33.8
(110)-PeCB	302	295	184	280	266	223

TABLE 4-2
DREDGED-AND-DEWATERED SEDIMENT PCB RESULTS (CONTINUED)

Analyte	Sample Identification					
PCBs (Method 680) (ng/g)	**Rolloff #3**			**Rolloff #4**		
	Lift 1	**Lift 2**	**Lift 3**	**Lift 1**	**Lift 2**	**Lift 3**
(82)-PeCB	31.0	30.0	19.2	28.3	26.5	23.2
(123)-PeCB	<4.39	<4.67	<3.59	<3.50	20.8	<4.20
118-PeCB	163	152	97.3	147	139	115
(114)-PeCB	10.6	10.4	<3.59	<3.50	8.01	7.65
(136)-HxCB	17.6	16.0	<11.8	15.3	15.7	12.5
(151)-HxCB	22.4	21.2	14.3	20.3	19.1	15.9
(135)-HxCB	16.9	15.8	<13.0	15.4	14.8	12.3
(139,149)-HxCB	76.9	67.2	45.9	69.2	66.1	55.4
(146,161)-HxCB	19.6	17.1	11.0	18.1	16.8	13.6
(132),153,(168)-HxCB	113	97.4	67.3	101	94.3	80.5
(141)-HxCB	14.6	13.3	8.66	13.3	12.0	10.6
(137)-HxCB	4.62	<4.67	<3.59	4.2	<4.61	<4.20
(138,160)-HxCB	58.9	51.3	34.8	37.6	47.1	43.0
(158)-HxCB	6.93	8.87	5.31	48.7	6.81	5.14
(128)-HxCB	10.6	8.90	7.03	9.15	10.2	8.43
(167)-HxCB	7.22	<5.88	<3.59	<3.50	<4.61	4.71
(156)-HxCB	<9.38	<12.4	<8.54	<8.23	<4.61	6.78
(157)-HxCB	<4.39	<4.67	<29.0	9.96	<4.61	19.4
(176)-HpCB	4.76	<4.67	<3.59	<3.50	<4.61	<4.20
(178)-HpCB	5.98	5.60	<3.66	5.36	<5.16	4.23
(182,187)-HpCB	34.3	29.7	18.7	31.5	29.4	24.7
(183)-HpCB	14.4	12.8	<8.78	12.9	12.1	10.5
(174,181)-HpCB	21.9	20.5	12.4	20.1	21.0	15.0
(177)-HpCB	14.2	12.9	7.67	13.2	13.7	9.89
180,(193)-HpCB	57.3	51.4	<33.5	53.0	50.0	40.3
(170,190)-HpCB	26.2	22.2	13.4	22.5	21.7	18.5
(196,203)-OcCB	11.4	<12.0	<7.39	10.4	<11.3	7.57
(206)-NoCB	9.52	7.84	5.55	7.47	7.65	5.56
(209)-DeCB	5.40	4.99	<3.59	4.43	<4.61	<4.20
PCBs (Method 680) homolog sum (ng/g)	**35,900**	**35,700**	**20,100**	**31.100**	**29,300**	**24,300**

Notes:
ng/g = Nanogram per gram
PCBs = Polychlorinated biphenyls
PCB congeners less than detection limits in all samples are not included in this table. For a complete list of these analytes, see Appendix A.
Results are reported on a dry-weight basis.

TABLE 4-3
DRUM-DRIED SEDIMENT PCB RESULTS

Analyte	Sample Identification					
PCBs (Method 680)	Rolloff #3			Rolloff #4		
(ng/g)	A	B	C	A	B	C
(1)-MoCB	86.2	<71.4	88.2	<76.0	67.9	56.9
(4,10)-DiCB	400	332	436	363	308	310
(9,7)-DiCB	100	87.9	108	91.9	79.5	84.3
(6)-DiCB	855	753	924	803	691	741
(5,8)-DiCB	1,110	980	1,200	1,060	910	971
(19)-TrCB	161	141	174	148	127	136
(18)-TrCB	1,500	1,360	1,640	1,430	1,250	1,360
(17)-TrCB	877	806	958	837	731	798
(27,24)-TrCB	200	185	219	192	169	181
(16,32)-TrCB	1,140	1,060	1,250	1,100	976	1,050
(26,25)-TrCB	1,850	1,750	2,020	1,840	1,650	1,770
28,(31)-TrCB	4,770	4,530	5,280	4,810	4,340	4,750
(21,33,20)-TrCB	549	527	603	553	502	539
(22)-TrCB	587	558	640	588	535	568
(37)-TrCB	379	372	414	393	364	386
(53)-TeCB	179	172	197	177	162	169
(45)-TeCB	185	175	205	183	166	174
(46)-TeCB	72.8	68.2	78.2	69.5	64.3	66.5
(43),52-TeCB	1,050	1,030	1,160	1,060	976	1,010
(49)-TeCB	824	812	911	822	767	790
(47,48,75)-TeCB	452	445	497	455	420	432
(44)-TeCB	763	760	847	758	708	741
(59,42)-TeCB	413	403	463	402	389	396
(41,71,72)-TeCB	450	452	502	451	432	441
(64,68)-TeCB	635	632	699	635	596	612
(40)-TeCB	156	155	174	156	147	153
(63)-TeCB	78	78.6	87.1	79.9	76.1	76.8
(74)-TeCB	349	359	388	358	340	348
(76)-TeCB	450	482	500	472	436	456
(70)-TeCB	484	483	532	484	472	472
(56,60)-TeCB	378	390	417	390	371	378
(77)-TeCB	108	113	120	113	109	111
(91)-PeCB	41.6	42.7	46.5	42.0	40.7	40.4
(84)-PeCB	64.3	65.2	71.6	63.5	62.7	61.8
(101,113)-PeCB	115	122	125	119	114	110
(99)-PeCB	71.6	74.8	79.7	72.1	70.6	69.9
(119,112)-PeCB	11.2	11.6	12.3	11.3	10.8	10.5
(86,97,125)-PeCB	47.1	49.1	52.1	47.6	47.1	45.4
(87,111,115)-PeCB	56.5	58.8	64.6	56.7	55.9	54.4
(85)-PeCB	35.4	37.5	39.4	35.7	35.1	34.6
(110)-PeCB	235	246	261	238	234	230

TABLE 4-3
DRUM-DRIED SEDIMENT PCB RESULTS (CONTINUED)

Analyte	Sample Identification					
PCBs (Method 680)	Rolloff #3			Rolloff #4		
(ng/g)	A	B	C	A	B	C
(82)-PeCB	25.4	25.6	26.7	24.2	24.7	23.9
(123)-PeCB	<2.58	<3.65	<22.8	<3.82	13.0	<2.33
118-PeCB	120	136	135	128	127	121
(114)-PeCB	7.45	<8.94	<2.75	<2.65	<2.68	<2.33
(136)-HxCB	13.0	14.6	14.2	14.4	13.1	12.7
(151)-HxCB	16.5	17.2	18.8	18.0	17.0	16.0
(135)-HxCB	13.2	14.7	17.1	13.5	12.8	12.9
(139,149)-HxCB	57.3	61.9	61.5	59.7	58.5	55.8
(146,161)-HxCB	15.7	16.3	16.6	16.2	15.2	15.3
(132),153,(168)-HxCB	84.8	92.3	91.3	89.1	86.7	84.1
(141)-HxCB	11.3	11.5	<11.5	11.2	10.0	11.1
(137)-HxCB	3.62	<2.61	<2.75	2.91	<3.04	3.59
(138,160)-HxCB	41.3	46.4	43.4	45.7	43.2	40.2
(158)-HxCB	6.58	7.36	<6.63	<6.60	7.25	5.67
(128)-HxCB	8.38	<8.68	8.87	<7.82	6.97	8.35
(156)-HxCB	7.12	<2.61	<23.9	<2.65	<17.7	<6.99
(176)-HpCB	3.63	<4.74	<3.99	<4.65	<5.92	3.37
(178)-HpCB	4.43	5.15	<5.45	<4.55	<5.50	4.64
(182,187)-HpCB	26.5	28.4	29.5	28.7	26.7	26.1
(183)-HpCB	10.9	12.1	<13.0	11.1	11.9	10.7
(185)-HpCB	<2.58	2.70	<2.90	<2.65	<2.68	<2.33
(174,181)-HpCB	17.0	17.7	20.2	18.1	17.9	16.2
(177)-HpCB	<11.0	<26.3	12.0	<11.6	<18.0	11.0
(172)-HpCB	2.85	2.86	<2.75	3.33	<2.97	2.36
180,(193)-HpCB	43.2	48.8	<51.4	46.9	44.6	43.5
(170,190)-HpCB	18.8	21.2	21.4	20	19.6	19.3
(196,203)-OcCB	8.20	8.78	<11.2	8.57	8.78	8.14
(208)-NoCB	<2.58	<2.61	2.98	<2.65	3.51	<2.33
206-NoCB	6.24	7.44	8.13	6.98	6.38	5.87
209-DeCB	2.74	<3.81	3.81	2.91	3.91	2.71
PCBs (Method 680) Congener sum (ng/g)	**22,800**	**21,700**	**25,000**	**22,500**	**20,500**	**21,700**

Notes:
ng/g = Nanogram per gram
PCBs = Polychlorinated biphenyls
ND = Not detected; analytes were less than detection limits of laboratory instruments. Laboratory did not specify detection limits.
PCB congeners less than detection limits in all samples are not included in this table. For a complete list of these analytes, see Appendix A.

4.3.2 Melter

The melter-phase of the demonstration was conducted at Minergy's facility in Winneconne, Wisconsin. The pilot-scale melter (glass furnace) was built to produce 2 tons of glass aggregate per day. The melter was designed to run on an oxygen-and-natural-gas mixture to burn more efficiently and produce higher temperatures, which should result in lower emissions of nitrogen oxides in the furnace flue gas. The melter was built with refractory brick that was selected based on an analysis of heat flow and the bricks' ability to cope with the corrosive qualities of molten sediment. The retention time of sediment in the melter was 6 hours, after which the molten sediment flowed from the melter into a water-quench tank. The molten sediment quickly cooled and cracked, producing a black glass aggregate product.

4.3.2.1 Melter Feed Dry Sediment

The drum-dried sediment was divided into 50-pound plastic bags for handling and tracking purposes. The dried sediment was fed into the melter at a rate of 200 pounds per hour over a 5-day period. Dried sediment was sampled every 15 minutes (once per 50-pound bag) as it was entering the screw feeder. A 4-ounce sample was collected from the bag and was placed in a disposable aluminum pan to be composited with other grab samples collected over the 6-hour sample collection period. Upon accumulation of all grab samples, the composite sample was mixed, using a coning-and-quartering technique. Analytical samples then were collected from the mixed composite sample.

PCBs

Composite samples, analyzed for both the Wisconsin State Laboratory of Hygiene list of PCB congeners and total PCBs by EPA Method 680 (EPA 1985), are listed in Table 1-1 of the QAPP (EPA 2001). Total PCB results, calculated by summing the concentration of homologs, ranged from 21,500 to 30,900 nanograms per gram (ng/g) (21.5 to 30.9 ppm). Table 4-4 contains analytical results from those composite samples of sediment.

The concentrations observed in the dried sediment are similar to concentrations observed in dredged-and-dewatered sediment samples.

TABLE 4-4
MELTER FEED DRY SEDIMENT COMPOSITE SAMPLE RESULTS

Analyte	Sample Identification					
PCBs (Method (680) (ng/g)	**M-S-01**	**M-S-02**	**M-S-03**	**M-S-04**	**M-S-05**	**M-S-06**
(1)-MoCB	99.0 E	77.2	79.9	92.3	62.7	51.7
(4,10)-DiCB	445 E	40.3 E	446 E	418 E	351 E	287 E
(9,7)-DiCB	111 E	109	117 E	107	99.4	79.5
(6)-DiCB	1,170 E	1,130 E	1,230 E	1,070 E	1,030 E	776 E
(5,8)-DiCB	1,330 E	1,290 E	1,420 E	1,260 E	1,190 E	922 E
(19)-TriCB	182 E	174 E	187 E	173 E	162 E	121 E
(18)TriCB	1,840 E	1,790 E	1,960 E	1,730 E	1,720 E	1,270 E
17(TriCB)	1,080 E	1,040 E	1,140 E	1,010 E	986 E	729 E
(27,24)-TriCB	232 E	228E	241 E	219 E	215 E	158 E
(16,32)-TriCB	1,360 E	1,340 E	1,430 E	1,290 E	1,290 E	950 E
(26,25)-TriCB	1,300 E	2,290 E	1450 E	2,130 E	2,180 E	1,590 E
(28,31)-TriCB	6,090 E	6,290 E	6,020 E	6,060 E	6,210 E	4,580 E
(21,33,20)-TriCB	677 E	693 E	737 E	656 E	668 E	493 E
(22)-TriCB	703 E	724 E	744 E	668 E	687 E	509 E
(37)-TriCB	458 E	477 E	494 E	439 E	457 E	341 E
(53)-TeCB	211 E	210E	219 E	202 E	204 E	147 E
(45)-TeCB	217 E	215E	225 E	208 E	209 E	150 E
(46)-TeCB	84.3	83.7	86.5	81.5	81.7	59.2
(43),52-TeCB	1,240 E	1,260 E	1,300 E	1,180 E	1,220 E	871
(49)-TeCB	997 E	1,010 E	1040 E	962 E	995 E	704 E
(47,48,75)-TeCB	518 E	516 E	531 E	481 E	497 E	369 E
(44)-TeCB	997 E	998 E	1,040 E	954 E	973 E	695 E
(59,42)-TeCB	422 E	432 E	432 E	393 E	414 E	305 E
(41,71,72)-TeCB	548 E	549 E	568 E	532 E	546 E	382 E
(64,68)-TeCB	753 E	764 E	784 E	708 E	742 E	544 E
(40)-TeCB	199 E	196 E	204 E	188 E	179 E	133 E
(63)-TeCB	94.4	96.8	99.4	89.9	93.9	67.8
(74)-TeCB	417 E	428 E	436	399 E	421 E	304 E
(70)-TeCB	639 E	630 E	649 E	573 E	638 E	480 E
(66,80)-TeCB	488 E	514 E	529 E	493 E	493 E	341 E
(56,60)-TeCB	446 E	461 E	468 E	428 E	446 E	330 E
(77)-TeCB	160 E	145 E	128 E	131 E	136 E	101
(91)-PeCB	49.2	49.4	50.3	46.8	48.6	34.5
(84)-PeCB	50.3	53.9	46.8	49.7	51	36.1
(101,113)-PeCB	148 E	151 E	153 E	140 E	149 E	107 E
(99)-PeCB	82.8	84.5	85.9	78.8	83.4	59.5
(119,112)-PeCB	12.4	12.6	12.5	12.1	11.7	9.26
(86,97,125)-PeCB	53.9	56.4	56.1	52.0	53.5	39.6
(87,111,115)-Pecb	77.5	66.4	80.6	63.3	65.8	56.4
(85)-PeCB	39.2	40.5	40.7	38.3	38.9	28.5
(110)-PeCB	279 E	283 E	289 E	265 E	277 E	201 E
(82)-PeCB	27.2	31.3	29.2	27.1	27.1	20.5

TABLE 4-4
MELTER FEED DRY SEDIMENT COMPOSITE SAMPLE RESULTS (CONTINUED)

Analyte	Sample Identification					
PCBs (Method (680) (ng/g)	**M-S-01**	**M-S-02**	**M-S-03**	**M-S-04**	**M-S-05**	**M-S-06**
(107)-PeCB	5.2	<4.14 P	<3.88 P	<4.77 P	<4.21 P	<1.27
(123) PeCB	<22.2 P	<22.6 P	<21.7 P	<19.3 P	<19.7 P	15
(118)-PeCB	148 E	151 E	155 E	139 E	148 E	108
(136)-HxCB	<1.36	<1.39	14.6	13.2	14.6	107 E
(151)-HxCB	17.8	18.3	19.6	17.2	17.9	14.3
(135)-HxCB	<1.36	13.9	16.8	14.9	13.6	<1.27
(139,149)-HxCB	58.9	62.0	65.2	56.2	60.9	46.1
(146,161)-HxCB	15.5	15.6	15.5	14.1	<1.35	12.7
(132,153,168)-HxCB	90.9	91.8	95.5	82.7	90.5	70.0
(141)-HxCB	11.5	<1.39	<10.8 P	10.4	<1.35	<1.27
(137)-HxCB	3.44	<3.00 P	<2.72 P	<1.39	<1.35	<1.27
(138,160)-HxCB	34.6	33.8	32.5	44.0	46.7	35.5
(158)-HxCB	49.2	51.4	47.7	<1.39 P	<1.35	<1.27
(176)-HpCB	<3.35 P	3.64	3.89	3.16	2.88	2.34
(178)-HpCB	4.23	4.51	4.74	4.04	<1.35	3.27
(182,187)-HpCB	26.8	28.4	28.6	25.9	<1.35	20.9
(183)-HpCB	<11.2 P	11.8	12.9	10.7	11.9	8.75
(185)-HpCB	2.15	2.27	<1.41 P	1.78	<1.35	<1.27
(174,181)-HpCB	18.9	17.8	18.8	16.4	17.2	13.6
(177)-HpCB	<1.36	<1.39	12.4	10.8	<1.35	9.50
(172)-HpCB	<1.36	<1.39	2.86	2.66	<1.35	2.46
(180,193)-HpCB	48.7	46.1	50.5	44.3	<1.35	37.4
(170,190)-HpCB	<20.8 P	<1.39	21.4	18.6	<1.35	15.4
(202)-OcCB	<1.36	<1.39	2.01	2.04	2.17	1.48
(196,203)-OcCB	<1.36	8.25	8.41	7.67	7.87	6.13
(208)-NpCB	<1.36	<1.39	<22.5 P	2.00	2.15	<1.27
(206)-NoCB	7.42	6.77	6.99	6.36	7.27	5.91
(209)-DeCB	2.85	10.6	3.22	3.96	3.06	2.23
Total PCBs (homolog sum) (ng/g)	**29,700**	**30,900**	**30,900**	**26,200**	**29,100**	**21,500**
Metals (mg/kg)	**M-S-01**	**M-S-02**	**M-S-03**	**M-S-04**	**M-S-05**	**M-S-06**
Arsenic	7.3	8.0	8.1	8.5	<5.9	<5.5
Barium	96	84	85	91	83	87
Cadmium	0.86	0.83	0.90	0.90	0.85	0.93
Chromium	39	37	38	39	36	37
Mercury	0.68	0.87	0.70	0.64	0.76	0.66
Lead	69	68	69	87	69	69
Selenium	10 J	6 J	6.5	6.7	<5.9	<5.5
Silver	<2.3	<2.3	<2.3	<2.3	<2.4	<2.2
PCDD/Fs (pg/g)	**M-S-01**	**M-S-02**	**M-S-03**	**M-S-04**	**M-S-05**	**M-S-06**
2,3,7,8-TCDD	14.8	28.0	12.8	13.4	52.8	18.9
1,2,3,7,8-PeCDD	29.5	41.0	27.6	29.5	93.6	49.0
1,2,3,4,7,8-HxCDD	234	240	245	234	241	235
1,2,3,6,7,8-HxCDD	254	251	284	262	289	310

TABLE 4-4
MELTER FEED DRY SEDIMENT COMPOSITE SAMPLE RESULTS (CONTINUED)

Analyte	Sample Identification					
PCDD/Fs (pg/g)	**M-S-01**	**M-S-02**	**M-S-03**	**M-S-04**	**M-S-05**	**M-S-06**
1,2,3,7,8,9-HxCDD	107	117	140	125	212	182
1,2,3,4,6,7,8-HpCDD	9,330	9,940	9,870	9,130	8,880	8,470
OCDD	56,500	63,100	67,300	62,300	61,000	48,500
2,3,7,8-TCDF	63.0	66.3	65.0	60.8	56.9	81.6
1,2,3,7,8-PeCDF	14.0	18.1	17.6	16.0	14.3	19.8
2,3,4,7,8-PeCDF	28.2	32.0	35.1	34.7	34.8	39.4
1,2,3,4,7,8-HcCDF	27.1	28.9	31.3	29.1	29.2	40.0
PCDDs/PCDFs (Method 8290) (pg/g)	**M-S-01**	**M-S-02**	**M-S-03**	**M-S-04**	**M-S-05**	**M-S-06**
1,2,3,6,7,8-HxCDF	25.9	26.5	28.7	27.6	28.9	30.4
2,3,4,6,7,8-HxCDF	41.7	45.3	42.1	40.5	54.6	64.2
1,2,3,7,8,9-HxCDF	4.57	<4.67	4.49	<4.01	<4.20	4.31
1,2,3,4,6,7,8-HpCDF	622	756	684	623	620	546
1,2,3,4,7,8,9-HpCDF	20.9	26.5	28.5	22.3	22.8	21.9
OCDF	1,530	2,190	1,690	1,580	1,370	1,220
Total PCDDs/PCDFs (homolog sum) (pg/g)	**101,000**	**111,000**	**115,000**	**106,000**	**107,000**	**168,000**
SVOCs (µg/L)	**M-S-01**	**M-S-02**	**M-S-03**	**M-S-04**	**M-S-05**	**M-S-06**
Fluoranthene	<190	<190	270 J	<190	--	--
Pyrene	<190	<190	300 J	<190	--	--
Benzo(a)anthracene	<190	<190	240 J	<190	--	--
Chrysene	<190	<190	280 J	<190	--	--
Benzo(b)fluoranthene	<190	<190	340 J	<190	--	--
Benzo(k)fluoranthene	<190	<190	190 J	<190	--	--
Benzo(a)pyrene	<190	<190	270 J	<190	--	--
Total SVOCs	**<190**	**<190**	**1,890**	**<190**	--	--
VOCs (µg/kg)	**M-S-01**	**M-S-02**	**M-S-03**	**M-S-04**	**M-S-05**	**M-S-06**
Acetone	840	630	330 ND,J	<5.7	--	--
2-Butanone	150	130	150	<5.7	--	--
Total VOCs	990	**760**	480	**<5.7**	--	--

Notes:
mg/g = Milligram per gram
ng/g = Nanogram per gram
pg/g = Picogram per gram
µg/kg = Microgram per kilogram
µg/L = Microgram per liter
PCBs - Polychlorinated biphenyls
PCDDs/PCDFs - Polychlorinated dibenzodioxins/Polychlorinated dibenzofurans
SVOCs - Semivolatile organic compounds
VOCs - Volatile organic compounds
E = Estimated Value. Concentration above Upper Calibration Range.
EMPC = Estimated Maximum Possible Concentration.
J = Estimated Value, Concentration Below Lower Calibration Range.
ND,J = Estimated nondetect. Low MS/MSD recoveries
P = Not detected at raised detection limit. Ion ratio is noncompliant. Equivalent to EMPC.
-- Not sampledPCB and PCDD/PCDF congeners, SVOCs, and VOCs less than detection limits in all samples are not included in this table. For a complete list of these analytes, see Appendix A.

Metals

Dried sediment composite samples were analyzed for the RCRA metals (arsenic, barium, cadmium, chromium, lead, mercury, selenium, and silver) by EPA Methods 6010B/7471A (EPA 1996). These results are presented in Table 4-4.

Mercury was considered a critical metal for this evaluation. It is consistently observed at concentrations of about 0.72 milligrams per kilogram (mg/kg) (0.721 ppm) in all pre-melter sediment samples.

Dioxins and Furans

The six composite samples were analyzed for dioxins and furans by EPA Method 8290 (EPA 1996). The results are presented in Table 4-4. Total dioxins and furans concentrations, calculated by summing the concentration of homologs, ranged from 101,000 to 168,000 picograms per gram (pg/g) (0.101 to 0.168 ppm).

Toxicity Equivalents (TEQs) are used to assess the risk of exposure to a mixture of dioxin-like compounds. Because dioxins differ in their toxicity, the toxicity of each component in the mixture are accounted for in estimating the overall toxicity. To do so, toxicity equivalency factors (TEFs) have been developed that compare the toxicity of different dioxins. Given these TEFs, provided in EPA Method 8290, the toxicity of a mixture can be expressed in terms of its TEQ, which is the amount of 2,3,7,8-tetrachlorodibenzo-*p*-dioxin it would take to equal the combined toxic effect of all the dioxins found in that mixture. TEQs were not assessed as part of the GFT demonstration evaluation. All of the TEQs observed exceed the Agency for Toxic Substances and Disease Registry (ATSDR) screening level of 50 parts per trillion (ppt).

SVOCs

Four composite samples of dried sediment were collected and analyzed for SVOCs by EPA Method 8270C (EPA 1996). The resulting SVOC concentrations, analyzed by EPA Method 8270C (EPA 1996) are listed in Table 4-4.

Total SVOC concentrations observed in dried sediment composite samples were generally small (below detection limits in most samples), ranging from less than 190 to 1,890 micrograms per kilogram (µg/kg) (0.190 to 1.89 ppm).

VOCs

Four composite samples were collected and analyzed for VOCs by EPA Method 8260B (EPA 1996). The results of VOC analyses are listed in Table 4-4. The only VOCs observed were acetone and 2-butanone, which are suspected laboratory artifacts. Acetone and 2-butanone are typically used by laboratories to clean equipment.

4.3.2.2 Flux

One composite sample was collected from the sodium sulfate flux material and analyzed for PCBs by EPA Method 680 (EPA 1985). Total PCB results are reported in Table 4-5. PCBs were detected at a concentration of 0.79 ppm.

4.3.2.3 Glass Aggregate Product

Molten sediment exited the melter into a water-quench tank, where it cooled quickly and shattered into small pieces. This glass aggregate product was removed from the water-quench tank by a screw conveyor and discharged into 55-gallon drums. The aggregate was produced at a rate of 170 lb/hr (77 kg/hour) over the demonstration period.

The screw-conveyor discharge was sampled every 15 minutes for six hours. These samples were composited in a disposable aluminum pan. Analytical samples were collected from the mixed composite sample. The following sections detail the results of the laboratory analyses of the composited glass aggregate product samples (aggregate).

PCBs

Composite glass samples, analyzed for both the Wisconsin State Laboratory of Hygiene list of PCB congeners and total PCBs by high-resolution EPA Method 1668 (EPA 1997), are listed in Appendix A. Total PCBs, calculated by summing the concentration of homologs, were reported by the laboratory and ranged from less than 26.0 to 1,240 pg/g (2.60×10^{-6} to 1.24×10^{-3} ppm). The analytical results are shown in Table 4-6.

TABLE 4-5

FLUX MATERIAL SAMPLE RESULT

Analyte	Sample Identification
PCBs (Method 680) (pg/g)	**M-F-01**
8-DiCB	36.7
18,(30)-TriCB	33.3
(26,29)-TriCB	27.1
31-TriCB	61.2
(20),28-TriCB	70.3
52-TeCB	37.2
49,(69)-TeCB	22.7
44,47,(65)-TeCB	28.3
209-DeCB	27.0
Total PCBs (homolog sum) (pq/g)	**790**
Metals (mg/kg)	**M-F-01**
Arsenic	<5.0
Barium	<0.50
Cadmium	<0.50
Chromium	<1.0
Lead	<5.0
Mercury	<0.25
Selenium	<5.0
Silver	<2.0
PCDDs/PCDFs (pg/g)	**M-F-01**
1,2,3,4,6,7,8-HpCDD	<0.639
OCDD	<3.50
OCDF	<0.399
Total PCDDs/PCDFs (pq/g) (homolog sum)	**5.07**
SVOCs (µg/kg)	**M-F-01**
Total SVOCs	**<170**

Notes:
mg/kg = Milligram per kilogram
pg/g = Picogram per gram
µg/kg = Microgram per kilogram
PCBs - Polychlorinated biphenyls
PCDDs/PCDFs - Polychlorinated dibenzodioxins/Polychlorinated dibenzofurans
SVOCs - Semivolatile organic compounds
PCB and PCDD/PCDF congeners, SVOCs, and VOCs less than detection limits in all samples are not included in this table. For a complete list of these analytes, see Appendix A.
Subtotal consists of the sum of the congeners investigated.
Total PCB and PCDD/PCDF values provided by the laboratory.

TABLE 4-6
GLASS AGGREGATE PRODUCT COMPOSITE SAMPLE RESULTS

Analyte	Sample Identification					
PCBs (Method 1668) (pg/g)	**M-G-01**	**M-G-02**	**M-G-03**	**M-G-04**	**M-G-05**	**M-G-06**
(6)-DiCB	<25.7	<26.0	<25.0	<24.2	<24.5	41.9
8-DiCB	49.9	<26.0	<25.0	<24.2	<24.5	40.8
18,(30)-TriCB	42.6	<26.0	<25.0	<24.2	<24.5	36.3
(26,29)-TriCB	32.7	<26.0	<25.0	<24.2	<24.5	<25.0
31-TriCB	109	<26.0	<25.0	<24.2	31.4	53.8
(20),28-TriCB	146	<26.0	26.3	<24.2	182	62.7
22-TriCB	28.2	<26.0	<25.0	<24.2	79.2	<25.0
37-TriCB	54.6	<26.0	<25.0	<24.2	84.3	<25.0
(45,51)-TeCB	<25.7	<26.0	<25.0	<24.2	24.6	<25.0
49,(69)-TeCB	47.4	<26.0	<25.0	<24.2	73.9	25.8
44,47,(65)-TeCB	59.6	<26.0	<25.0	<24.2	118	35.0
(40,71)-TeCB	26.9	<26.0	<25.0	<24.2	70.2	<25.0
64-TeCB	<25.7	<26.0	<25.0	<24.2	62.3	<25.0
(61),70,74,(76)-TeCB	57.7	<26.0	<25.0	<24.2	114	<25.0
66-TeCB	43.2	<26.0	<25.0	<24.2	125	<25.0
56-TeCB	<25.7	<26.0	<25.0	<24.2	74.3	<25.0
60-TeCB	<25.7	<26.0	<25.0	<24.2	50.4	<25.0
77-TeCB	<25.7	<26.0	<25.0	<24.2	26.6	<25.0
(85,116)-PeCB	28.8	<26.0	<25.0	<24.2	29.2	<25.0
PCBs (Method 1668) (pg/g)						
Total PCBs	**790**	**<26.0**	**58.1**	**26.5**	**1,240**	**345**
Metals (mg/kg)						
Arsenic	<5.2	<5.0	<5.0	<5.0	<5.0	<5.0
Barium	330	320	320	330	350	320
Cadmium	<0.52	<0.50	<0.50	<0.50	<0.50	<0.50
Chromium	50	48	49	49	53	52
Lead	12	12	15	16	16	14
Mercury	<0.26	<0.25	<0.25	<0.25	<0.25	<0.25
Selenium	9.2 J	8 J	8.1	7.7	<5.0	<5.0
Silver	<2.1	<2.0	<2.0	<2.0	<4.0	<2.0
PCDDs/PCDFs (Method 8290) (pg/g)						
1,2,3,7,8-PeCDD	<0.151	0.173 A	<0.165	<0.189	--	--
1,2,3,7,8-PeCDF	<0.0684	0.149 A	<0.0826	<0.111	--	--
2,3,4,7,8-PeCDF	<0.0668	0.125 A	<0.0806	<0.109	--	--
Total PCDDs/PCDFs (homolog sum) (pg/g)						
Total PCDDs/PCDFs	**2.01**	**3.77**	**1.93**	**1.77**	--	--

TABLE 4-6
GLASS AGGREGATE PRODUCT COMPOSITE SAMPLE RESULTS (CONTNUED)

Notes:

mg/kg = Milligram per kilogram
pg/g = Picogram per gram
PCBs - Polychlorinated biphenyls
PCDDs/PCDFs - Polychlorinated dibenzodioxins/Polychlorinated dibenzofurans
SVOCs - Semivolatile organic compounds
VOCs - Volatile organic compounds
A = Estimated Value, Concentration Below Lower Calibration Range. Values above EDL were used to calculate totals.
EDL = Estimated Detection Limit
J = Estimated Value, Concentration Below Lower Calibration Range.
-- Not sampled
PCB and PCDD/PCDF congeners, SVOCs, and VOCs less than detection limits in all samples are not included in this table. For a complete list of these analytes, see Appendix A.
Subtotal consists of the sum of the congeners investigated.
Total PCB and PCDD/PCDF values provided by the laboratory.

Mainly tri- and tetra-substituted congeners were detected in the glass aggregate product composite samples. The highest concentrations found were the congeners 2,3,3'-trichloro biphenyl and 2,4,4'-trichloro biphenyl (coeluted and reported as (20),28-TriCB) , which was detected at 146 and 182 picograms per gram (pg/g) (1.46×10^{-4} to 1.82×10^{-4} ppm) in samples M-G-01 and M-G-05, respectively.

Minergy has included, in the Vendor Claims appendix of this ITER, additional information about a toxicological report.

Metals

The glass aggregate product composite samples also were analyzed for the eight RCRA metals by EPA Methods 6010B/7471A (EPA 1996). The results are shown in Table 4-6.

Barium (320 to 350 mg/kg [320 to 350 ppm]) and chromium (48 to 53 mg/kg [48 to 53 ppm]) were consistently observed in glass aggregate product composite samples. Mercury concentrations were all below detection limits.

Dioxins and Furans

Glass aggregate product samples were submitted for analysis of dioxins and furans by EPA Method 8290 (EPA 1996). The results of the dioxins and furans analysis are detailed in Table 4-6.

Total dioxin and furan concentrations, calculated by summing the concentration of homologs, ranged from 1.77 to 3.77 pg/g (1.77×10^{-6} to 3.77×10^{-6} ppm). TEQs are used to assess the risk of exposure to a mixture of dioxin-like compounds. All of the TEQs observed in glass aggregate composite samples are well below the ATSDR screening level of 50 ppt.

Minergy has included, in the Vendor Claims appendix of this ITER, additional information about a toxicological report.

SVOCs

Composite samples of the glass aggregate product were collected and submitted for analysis of SVOCs. The resulting SVOC concentrations, analyzed by Method EPA 8270C (EPA 1996), were all below detection limits.

VOCs

A glass aggregate product sample was collected and submitted for analysis by EPA Method 8260B (EPA 1996) of VOCs to verify that PCBs had not been broken down into VOCs in the glass. None of the VOC analytes was detected above detection limits.

4.3.2.4 Melter Flue Gas

As the PCB-contaminated sediment entered the melter, PCBs were removed or destroyed in the furnace atmosphere, which reached a temperature of about 1,600 °C (2,900 °F). The melter flue gas was sampled to evaluate the effectiveness of the furnace in destroying PCBs and other organic contaminants, such as dioxins and furans and SVOCs. A water-cooled probe was inserted into the melter flue to extract a portion of the flue gas for sampling. The flue gas was sampled after its temperature was reduced from 1,600 °C (2,900 °F) to about 200 °C (400 °F).

Several samples were collected for analysis of PCBs, metals, dioxins and furans, SVOCs, VOCs, and HCl/Cl_2. Depending on the analysis, the melter flue gas was sampled for various durations using sample trains specific to each method and parameter. The sample train apparatus from each sample was then recovered, and the samples were sent to a laboratory for completion of the analysis. The following sections detail the results of the laboratory analyses of melter flue gas samples.

PCBs

PCB analytical results determined by high-resolution EPA Method 1668 (EPA 1997) were reported for individual congeners on the Wisconsin State Laboratory of Hygiene list. Total PCBs, calculated by summing the concentration of homologs, also were reported by the laboratory. Total PCB results from the air samples ranged from 16.4 to 130 nanograms per dry standard cubic meter (ng/dscm) (5.54×10^{-6} to 1.27×10^{-5} ppm). Table 4-7 contains the analytical results from the melter flue gas air samples.

TABLE 4-7
MELTER FLUE GAS SAMPLE RESULTS

Analyte	Sample Identification					
PCBs (Method 680) (ng/dscm)	**Run #1**	**Run #2**	**Run #3**	**Run #4**	**Run #5**	**Run #6**
1-MoCB	1.06	0.576	0.398	0.516	0.383	0.707
(4)-DiCB	2.19	1.34	0.699	1.08	<0.228	<0.226
(7)-DiCB	0.531	0.324	<0.239	0.289	<0.228	<0.226
(6)-DiCB	6.85	3.39	1.95	2.08	1.21	2.75
8-DiCB	7.85	4.11	2.48	2.41	1.83	3.50
(19)-TriCB	1.03	0.440	0.279	0.308	<0.228	0.422
18,(30)-TriCB	14.1	5.13	3.03	3.15	1.88	3.82
(17)-TriCB	6.26	2.18	1.28	1.40	0.774	1.62
(27)-TriCB	1.45	0.452	0.255	0.261	<0.228	0.307
(24)-TriCB	2.84	1.16	0.649	<0.678	0.455	0.842
(26,29)-TriCB	7.14	2.16	<1.19	<1.32	<0.742	<1.49
(25)-TriCB	4.99	1.49	0.825	<0.895	<0.5283	<1.06
31-TriCB	13.4	4.64	2.55	2.71	1.78	3.00
(20),28-TriCB	13.2	4.74	2.60	2.82	1.88	3.21
(21),33-TriCB	2.22	1.47	0.697	0.736	0.638	0.750
22-TriCB	3.01	1.38	0.728	0.775	0.547	0.847
37-TriCB	0.949	0.866	0.332	0.370	0.296	0.413
(50,53)-TeCB	2.74	0.648	0.379	0.421	0.291	0.350
(45,51)-TeCB	3.40	0.834	0.530	0.583	0.417	0.476
(46)-TeCB	0.930	0.254	<0.238	<0.231	<0.228	<0.226
52-TeCB	8.73	2.66	<1.39	1.66	1.20	<1.43
49,(69)-TeCB	5.46	1.69	0.866	1.04	0.754	0.928
(48)-TeCB	<0.245	0.336	<0.238	<0.231	<0.228	<0.226
44,47,(65)-TeCB	7.22	2.47	1.30	<1.52	<1.14	<1.39
(59,62,75)-TeCB	<0.245	0.341	<0.238	<0.231	<0.228	<0.226
(40,71)-TeCB	2.24	1.08	0.592	0.571	0.476	0.571
64-TeCB	1.80	0.842	0.420	0.484	0.403	0.458
(61),70,74,(76)-TeCB	2.25	1.29	0.716	<0.747	<0.699	<0.664
66-TeCB	1.13	0.646	0.377	0.377	0.387	0.341
56-TeCB	0.448	0.384	<0.238	<0.231	<0.228	<0.226
77-TeCB	0.308	0.317	0.389	0.319	0.228	<0.226
84-PeCB	0.440	<0.242	<0.238	<0.231	<0.228	<0.226
90,101,(113)-PeCB	0.866	0.571	0.312	0.303	<0.228	0.348
86,87,97,(108),119,(125)-PeCB	0.729	0.242	0.296	0.303	0.319	0.246
(85,116)-PeCB	1.06	0.706	0.394	0.368	<0.228	<0.226
110-PeCB	<0.245	<0.242	<0.238	<0.231	0.276	0.273
118-PeCB	0.401	0.351	<0.238	<0.231	<0.228	<0.226
(147),149-HxCB	0.286	<0.242	<0.238	<0.231	<0.228	<0.226
(129),138,(163)-HxCB	0.320	0.281	<0.238	<0.231	<0.228	<0.226

TABLE 4-7
MELTER FLUE GAS SAMPLE RESULTS (CONTINUED)

Analyte	Sample Identification					
Metals (µg/dscm)	**Run #1**	**Run #2**	**Run #3**	**Run #4**	**Run #5**	**Run #6**
Cadmium	<1,900	<2,500	<1,800	<1,320	--	--
Chromium (Total)	<10,000	<13,000	<9,500	<5,460	--	--
Lead	<150,000	<40,000	<21,000	<26,200	--	--
Mercury	<3,200	<2,800	<1,800	<8,990	--	--
Selenium	<19,000	<26,000	<18,000	<13,200	--	--
Silver	<1,900	<3,100	<1,990	<1,320	--	--
PCDDs/PCDFs (Method 8290) (ng/dscm)						
2,3,7,8-TCDD	0.009 EMPC	0.012 EMPC	<0.0038	<0.0087	<0.0061	<0.0024
1,2,3,7,8-PeCDD	0.015	0.047	0.012	0.028	0.007	0.004
1,2,3,4,7,8-HxCDD	0.019	0.044	0.012	0.021	0.006	0.007
1,2,3,6,7,8-HxCDD	0.057	0.131	0.043	0.084	0.023	0.026
1,2,3,7,8,9-HxCDD	0.028	0.065	0.023	0.071	0.014	0.014
1,2,3,4,6,7,8-HpCDD	0.531	0.624	0.174	0.298	0.092	0.115
OCDD	0.883	0.723	0.170	0.218	<0.10	<0.12
2,3,7,8-TCDF	0.022	0.100	0.028	0.034	<0.011	0.015
1,2,3,7,8-PeCDF	0.030	0.158	0.035	0.054	0.017	0.021
2,3,4,7,8-PeCDF	0.056	0.222	0.050	0.070	0.022	0.026
1,2,3,4,7,8-HxCDF	0.073	0.271	0.067	0.115	0.037	0.049
1,2,3,6,7,8-HxCDF	0.060	0.186	0.047	0.072	0.024	0.029
2,3,4,6,7,8-HxCDF	0.081	0.162	0.034	0.046	0.017	0.016
1,2,3,7,8,9-HxCDF	0.025	0.067	0.014	0.020	0.007	0.007
1,2,3,4,6,7,8-HpCDF	0.274	0.551	0.132	0.227	0.077	0.088
1,2,3,4,7,8,9-HpCDF	0.037	0.069	0.016	0.023	0.011	0.012
OCDF	0.242	0.239	0.078	0.106	0.051	0.077
SVOCs (ng/dscm)						
Benzoic Acid	143,000	140,000	--	--	--	--
Bis (2-ethylhexyl) phthalate	22,000	3,590	--	--	--	--
2-Methylphenol	5,020	3,590	--	--	--	--
3- & 4-Methylphenol	3,860	3,590	--	--	--	--
2-Nitrophenol	4,630	4,310	--	--	--	--
Phenol	7,720	3,590	--	--	--	--
Total SVOCs	**186,000**	**159,000**	--	--	--	--
VOCs (ng/dscm)						
Bromomethane	46.5	18.6	--	--	--	--
Carbon Disulfide	14.0	34.4	--	--	--	--
Methylene Chloride	17.3	19.8	--	--	--	--
Benzene	18.2	18.7	--	--	--	--

Toluene	146	99.1	--	--	--	--
Total VOCs	**242**	**191**	--	--	--	--
Analyte	**Sample Identification**					
	Run #1	**Run #2**	**Run #3**	**Run #4**	**Run #5**	**Run #6**
HC1/Cl_2 (µg/dscm)						
HC1	54,600	140,000	27,600	57,300	--	--
$C1_2$	4,380	838	37.900	137	--	--

Notes:
Cl_2 - Chlorine
HCl - Hydrogen chloride
µg/dscm = Microgram per dry standard cubic meter
ng/dscm = Nanogram per dry standard cubic meter
PCBs - Polychlorinated biphenyls
PCDDs/PCDFs - Polychlorinated dibenzodioxins/Polychlorinated dibenzofurans
SVOCs - Semivolatile organic compounds
VOCs - Volatile organic compounds
EMPC = Estimated Maximum Possible Concentration.
-- Not sampled
PCB and PCDD/PCDF congeners, SVOCs, and VOCs less than detection limits in all samples are not included in this table. For a complete list of these analytes, see Appendix A.
Total PCB and PCDD/PCDF values equal the sum of the congeners investigated.

Metals

Melter flue gas samples were analyzed for RCRA metals by Methods 6010B/7471A (EPA 1996). Individual metals were analyzed, and their resulting concentrations observed in the flue gas are detailed in Table 4-7.

Metals concentrations in the melter flue gas samples were all below detection limits.

Dioxins and Furans

Melter flue gas air samples were submitted for analysis of dioxins and furans by EPA Method 8290 (EPA 1996). Results of the dioxins and furans analysis are detailed in Table 4-7.

Total dioxin and furan concentrations, calculated by summing the concentration of homologs, for air samples collected during the demonstration ranged from 0.406 to 3.66 ng/dscm. (3.14×10^{-8} to 2.22×10^{-7} ppm).

SVOCs

Air samples of melter flue gas were collected and submitted for analysis of SVOCs. The resulting SVOC concentrations, analyzed by EPA Method 8270C (EPA 1996), are summarized in Table 4-7.

Two samples were analyzed for SVOCs. The resulting concentrations in air samples were 186,000 and 159,000 ng/dscm. (0.0342 and 0.0284 ppm).

VOCs

Melter flue gas samples were collected and submitted for analysis of VOCs. Two samples were analyzed for VOCs, and the resulting concentrations, which were analyzed by EPA Method 8260B (EPA 1996), are summarized in Table 4-7.

VOC concentrations observed in the two air samples collected from the melter flue gas were 242 and 191 ng/dscm (7.43×10^{-6} and 6.17×10^{-6} ppm).

HCl/Cl_2

Melter flue gas was also sampled for hydrogen chloride (HCl) and chlorine (Cl_2), which were analyzed by EPA Method 26A. The flue gas was sampled for HCl/Cl_2 verify that the destruction of PCBs in the furnace did not create other pollutants. The resulting concentrations of HCl ranged from 27,600 to 140,000 ng/dscm (18 to 94 ppm). Concentrations of Cl_2 in the melter flue gas ranged from 137 to 37,900 ng/dscm (<0.047 to 13 ppm). Table 4-7 contains the results of the HCl/Cl_2 analyses for four sampling runs.

4.3.2.5 Post-Carbon Treatment Flue Gas

The melter flue gas stream passed through a carbon filter unit prior to discharge to the atmosphere. This stream was sampled after the carbon filter to evaluate the effectiveness of carbon treatment. Three samples of this stream were extracted into sampling bags and analyzed for PCB congeners, PCDDs/PCDFs, metals and SVOCs. The results are reported in Table 4-8.

4.3.2.6 Quench-Tank Water

The quench tank was situated at the end of the melter furnace, beneath the forehearth, where the molten sediment exited the melter. The molten sediment dropped into the quench tank, where it cooled immediately into black glass and shattered into small pieces collectively called glass aggregate product. The aggregate fell into a hopper at the bottom of the quench tank. The hopper was attached to a screw conveyor, which lifted the aggregate out of the quench tank and dropped it into 55-gallon drums. The water level in the tank was maintained by a float valve that allowed water into the tank as the level was reduced.

The quench tank was sampled from a valve installed on the tank drain. A 1-liter grab sample was collected every half hour over the same 6-hour period, during which the glass aggregate was sampled. Grab samples were composited in a large, glass container, which was mixed upon collection of all grab samples. Samples for laboratory analysis were collected by pouring the composited quench-tank water into laboratory sample containers. Quench-tank water was analyzed for PCBs, metals, and SVOCs.

TABLE 4-8
POST-CARBON GAS SAMPLE RESULTS

Analyte	Sample Identification		
PCBs (Method 680) (ng/dscm)	**Run #1**	**Run #2**	**Run #3**
1-MoCB	1.18	<0.232	<0.0650
(4)-DiCB	4.09	0.781	<0.0650
(7)-DiCB	0.468	<0.232	<0.0650
(6)-DiCB	8.08	1.60	<0.226
(5)-DiCB	<0.246	2.02	<0.0650
8-DiCB	8.87	1.97	0.322
(19)-TriCB	0.863	<0.232	<0.0650
18,(30)-TriCB	8.92	2.41	0.362
(17)-TriCB	3.97	1.04	1.49
(27)-TriCB	0.722	<0.232	<0.0650
(24)-TriCB	1.68	0.505	0.0839
(26,29)-TriCB	3.38	<0.971	<0.133
(25)-TriCB	2.39	0.668	<0.0878
31-TriCB	6.51	2.06	<0.345
(20),28-TriCB	6.80	2.18	<0.371
(21),33-TriCB	1.40	0.651	0.147
22-TriCB	1.67	0.580	0.113
37-TriCB	0.488	0.269	<0.0650
(50,53)-TeCB	0.927	0.334	<0.0650
(45,51)-TeCB	1.34	0.468	0.0696
(46)-TeCB	0.355	<0.232	<0.0650
52-TeCB	3.43	<1.35	<0.245
49,(69)-TeCB	2.28	0.962	0.141
(48)-TeCB	0.365	<0.232	<0.0650
44,47,(65)-TeCB	3.28	1.40	<0.224
(59,62,75)-TeCB	0.419	<0.232	<0.0650
(40,71)-TeCB	1.90	0.941	0.125
64-TeCB	1.10	0.508	0.0800
(61),70,74,(76)-TeCB	1.21	0.679	0.159
66-TeCB	0.628	0.366	0.0891
56-TeCB	1.11	0.777	0.117
90,101,(113)-PeCB	0.589	0.267	<0.0650
86,87,97,(108),119,(125)-PeCB	<0.246	0.311	<0.0650
(85,116)-PeCB	0.579	0.327	<0.0650
118-PeCB	0.271	<0.232	<0.0650
158-HxCB	0.261	<0.232	<0.0650
Metals (µg/dscm)	**Run #1**	**Run #2**	**Run #3**
Arsenic	<1,410	<1,390	<1,340
Barium	<141	<150	<134
Cadmium	<141	<139	<134
Chromium (Total)	<281	<279	<268

TABLE 4-8
POST-CARBON GAS SAMPLE RESULTS

Analyte	Sample Identification		
Metals (µg/dscm) (Continued)	**Run #1**	**Run #2**	**Run #3**
Lead	<1,410	<1,390	<1,340
Mercury	<1.46	<2.32	<1.04
Selenium	<1,410	<1,390	<1,340
Silver	<141	<139	<134
PCDDs/PCDFs (Method 8290) (ng/dscm)	Run #1	Run #2	Run #3
2,3,7,8-TCDD	<0.00232	<0.00705	<0.00302
1,2,3,7,8-PeCDD	<0.00185	<0.00199	<0.00141
1,2,3,4,7,8-HxCDD	0.00212 EMPC	<0.00223	<0.00166
1,2,3,6,7,8-HxCDD	<0.00286	<0.00283	<0.0272
1,2,3,7,8,9-HxCDD	<0.00180	0.00121	<0.00156
1,2,3,4,6,7,8-HpCDD	<0.00872	<0.0121	<0.0832
OCDD	<0.0451	<0.0399	<0.0317
2,3,7,8-TCDF	0.00532	<0.00118	<0.00205
1,2,3,7,8-PeCDF	<0.00759	<0.00278	<0.000966
2,3,4,7,8-PeCDF	<0.00335	<0.00274	<0.000941
1,2,3,4,7,8-HxCDF	<0.00912	<0.00626	<0.00116
1,2,3,6,7,8-HxCDF	<0.00409	<0.00325	<0.00109
2,3,4,6,7,8-HxCDF	<0.00148	<0.000904	<0.00121
1,2,3,7,8,9-HxCDF	<0.00163	<0.000997	<0.00134
1,2,3,4,6,7,8-HpCDF	<0.0690	<0.00427	<0.0253
1,2,3,4,7,8,9-HpCDF	<0.00207	<0.00146	<0.00171
OCDF	0.0124	<0.00366	<0.00317
SVOCs (ng/dscm)	Run #1	Run #2	Run #3
Benzoic Acid	<3,220	25,900	6,410

Notes
µg/dscm = Microgram per dry standard cubic meter
ng/dscm = Nanogram per dry standard cubic meter
PCBs - Polychlorinated biphenyls
PCDDs/PCDFs - Polychlorinated dibenzodioxins/Polychlorinated dibenzofurans
SVOCs - Semivolatile organic compounds
EMPC = Estimated Maximum Possible Concentration.
PCB and PCDD/PCDF congeners, SVOCs less than detection limits in all samples are not included in this table. For a complete list of these analytes, see Appendix A.

PCBs

Quench water was analyzed for PCB content to determine whether, as a waste stream, the quench water had acquired PCBs from the molten sediment. Quench-water samples were analyzed for both the Wisconsin State Laboratory of Hygiene list of PCB congeners and total PCBs by high-resolution EPA Method 1668 (EPA 1997). Results of the PCB analysis were used in the evaluation of Primary Objective P1, and are reported in Table 4-9.

Total PCBs, calculated by summing the concentration of homologs, ranged from less than 0.500 to 1.09 nanograms per liter (ng/L) (0.5×10^{-6} to 1.09×10^{-6} ppm].

Metals

Quench-tank-water composite samples were analyzed for RCRA metals by EPA Methods 6010B/7470A (EPA 1996). Individual metals analyzed and their resulting concentrations observed in the glass aggregate product are detailed in Table 4-9.

All of the quench-tank-water samples exhibited minor detections of barium, but all other metals were below detection limits.

SVOCs

Four samples of the quench-tank water were collected and submitted for analysis of SVOCs. The resulting SVOC concentrations, analyzed by EPA Method 8270C (EPA 1996), are summarized in Table 4-9. Only one detection of a single SVOC, di-n-octylphthalate, was observed in sample M-QW-02. Phthalates are sometimes considered to be common laboratory or sampling contaminants.

TABLE 4-9
QUENCH WATER COMPOSITE SAMPLE RESULTS

Analyte	Sample Identification					
PCBs (Method 1668) (pg/g)	**M-QW-01**	**M-QW-02**	**M-QW-03**	**M-QW-04**	**M-QW-05**	**M-QW-06**
8-DiCB	<0.500	0.513	<0.500	<0.500	<0.500	<0.500
18,(30)-TriCB	0.563	0.575	<0.500	0.539	<0.500	<0.500
Total PCBs (homolog sum) (pg/g)	**0.563**	**1.09**	**<0.500**	**0.539**	**<0.500**	**<0.500**
Metals (mg/L)						
Arsenic	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Barium	0.029	0.035	0.031	0.03	<0.01	<0.01
Cadmium	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Chromium	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Mercury	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
Lead	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Selenium	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Silver	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
SVOCs (µg/L)						
Di-n-octylphthalate	<5.0	21 J	<5.0	<5.3	--	--
Total SVOCs	**<5.0**	**21 J**	**<5.0**	**<5.3**	**--**	**--**

Notes:
mg/L = Milligram per liter
pg/g = Picogram per gram
µg/L = Microgram per liter
PCBs - Polychlorinated biphenyls
PCDDs/PCDFs - Polychlorinated dibenzodioxins/Polychlorinated dibenzofurans
SVOCs - Semivolatile organic compounds
-- Not sampled
J = Estimated Value, Concentration Below Lower Calibration Range.
PCB congeners and SVOCs less than detection limits in all samples are not included in this table. For a complete list of these analytes, see Appendix A.
Samples were not analyzed for PCDDs/PCDFs or VOCs.

4.3.2.7 Cooling-Tower Discharge

As previously described, a water-cooled air sampling probe was inserted into the melter flue to extract a portion of the melter flue gas for sampling. The temperature of the flue gas was reduced to 190°C (400° F) for sampling. After sampling, the flue gas was further cooled using a cooling tower before it passed through carbon treatment. Because the melter was fired by natural gas, it was expected that the cooling tower would generate water as the flue gas cooled and that it would need to be drained periodically. In practice, the cooling water in the loop quickly became acidic and degraded parts in the recirculating pump. The system then was converted to a non-recirculating system, wherein fresh water entered the cooling tower and was discharged to a drain.

Cooling-tower samples were collected from the drain during the second, fourth, and sixth sampling runs. During the second sampling run, the cooling-tower system was configured as a recirculating loop, and any contaminants in the water in the system were expected to be more concentrated. During the fourth and sixth sampling runs, the system was configured with fresh water, so the contaminants in the water were expected to be more dilute. Cooling-tower-water samples were submitted to a laboratory for analysis of PCBs, metals, and SVOCs. The samples were grab samples and were not collected over time for compositing.

PCBs

Cooling-tower water was analyzed for PCB content to determine whether, as a waste stream, the cooling tower water had acquired PCBs from the melter flue gas. Cooling-tower water samples were analyzed for both the Wisconsin State Laboratory of Hygiene list of PCB congeners and total PCBs by high-resolution EPA Method 1668 (EPA 1997). The results of the PCB analyses were used in the evaluation of Primary Objective P1, and PCB results reported in Table 4-10.

Total PCBs, calculated by summing the concentration of homologs, in the cooling-tower-water samples ranged from less than 0.500 to 7.78 ng/L (5.00×10^{-7} to 7.78×10^{-6} ppm). The total PCB concentration in sample M-CTD-02 was higher than those in other samples. Sample M-CTD-02 was collected while the cooling tower was configured as a recirculating loop, and the water in the cooling tower was expected to exhibit higher concentrations than water after it was converted to use fresh water.

TABLE 4-10
COOLING-TOWER-WATER SAMPLE RESULTS

Analyte	Sample Identification		
PCBs (Method 1668) (pg/g)	**M-CTD-02**	**M-CTD-04**	**M-CTD-06**
8-DiCB	0.607	<0.500	<0.500
18,(30)-TriCB	0.788	<0.500	<0.500
(26,29)-TriCB	0.712	<0.500	<0.500
31-TriCB	1.45	<0.500	<0.500
(20),28-TriCB	1.46	<0.500	<0.500
52-TeCB	1.10	<0.500	0.515
49,(69)-TeCB	0.635	<0.500	<0.500
44,47,(65)-TeCB	1.03	<0.500	<0.500
Total PCBs (all congeners)	**7.78**	**<0.500**	**0.515**
Total PCBs (homolog sum) (pg/g)			
Metals (mg/L)			
Arsenic	0.65	<0.10	<0.10
Barium	0.082	0.026	<0.01
Cadmium	0.079	<0.01	<0.01
Chromium	3.5	0.033	<0.02
Mercury	0.12	0.0045	<0.0002
Lead	5.9	0.25	<0.10
Selenium	<2.5	<0.10	<0.10
Silver	<0.02	<0.01	<0.01

Notes:
mg/L = Milligram per liter
pg/g = Picogram per gram
PCBs = Polychlorinated biphenyls
PCDDs/PCDFs = Polychlorinated dibenzodioxins/Polychlorinated dibenzofurans
-- Not sampled
PCB congeners and SVOCs less than detection limits in all samples are not included in this table. For a complete list of these analytes, see Appendix A.
Samples were not analyzed for PCDDs/PCDFs or VOCs.

Metals

Cooling-tower-water samples were analyzed for the eight RCRA metals by EPA Methods 6010B/7470A (EPA 1996). Individual metals analyzed and their resulting concentrations observed in the cooling-tower water are shown in Table 4-10.

As expected, metal concentrations in the initial sample (M-CTD-02) were higher than concentrations in subsequent samples.

SVOCs

Two samples of the cooling-tower water were collected and submitted for analysis of SVOCs by Method 8270C (EPA 1996). No SVOCs were detected in either of the two samples.

4.3.2.8 Dust

As the demonstration began and air sampling proceeded, it became apparent that the air-sampling probe was becoming clogged by solids in the melter flue gas as it rapidly cooled from 1600°C to 190°C (2900°F to 400°F). Solids accumulated in the probe until the gas would no longer flow, and sampling became difficult. Sampling was halted, and the probe was removed from the furnace and cleaned. The solid material, which apparently consisted of accumulated dust, was collected as the probe was cleaned and weighed. The accumulated dust was composited daily, so three composite samples of dust were obtained over the course of the demonstration.

The dust material was brown in color and consisted of some large pieces, so it was crushed with a mechanical crusher so it could be inserted into laboratory sample containers. Dust samples were submitted to a laboratory and analyzed for metals and dioxins and furans.

Minergy claims that the dust issues encountered during the demonstration would be controlled in a commercial scale operation.

Metals

Dust samples were analyzed for RCRA metals by EPA Methods 6010B/7471A (EPA 1996). Individual metals analyzed and their resulting concentrations observed in the dust-composite samples are detailed in Table 4-11.

Several metals were present at elevated levels. Metals concentrations in each of the dust composites were similar in magnitude.

Dioxins and Furans

The dust material was sampled to determine whether dioxins and furans were present. The material was analyzed for dioxins and furans by EPA Method 8290 (EPA 1996), and the laboratory provided results for individual congeners and total dioxins and furans, based on summing the homologs. Results of the dioxins and furans analysis are summarized in Table 4-11.

The table shows that the dust contained total dioxin and furan concentrations ranging from below detection limits (<0.327) to 10.1 ng/g (<3.27×10^{-7} to 1.01×10^{-5} ppm).

4.3.2.9 Leachates of Glass Aggregate Product and Crushed Glass Aggregate Product

The glass aggregate product was subjected to two water-leach tests: the ASTM Standard Test Method for Shake Extraction of Solid Waste with Water (D3987-99) (ASTM 1999) and the Synthetic Precipitate Leaching Procedure (SPLP) (EPA Method 1312) (EPA 1996). The glass aggregate product was extracted by the ASTM water leach method and analyzed for PCBs and metals. Glass-aggregate-product samples also were extracted by the SPLP method and analyzed for PCBs, metals, dioxins and furans, and SVOCs. Results of total PCBs and metals analysis of the leachates were used to evaluate Primary Objective P2, and the results are summarized in Table 4-12.

TABLE 4-11
DUST COMPOSITE SAMPLE RESULTS

Analyte	Sample Identification		
Metals (mg/kg)	**M-AS-01**	**M-AS-02**	**M-AS-03**
Arsenic	87	120	130
Barium	230	210	210
Cadmium	12	18	19
Chromium	190	250	240
Mercury	0.50	0.61	1.0
Lead	760	1,100	1,200
Selenium	44	40	43
Silver	4.7	7.1	8.1
PCDDs/PCDFs (Method 8290) (pg/g)			
1,2,3,7,8-PeCDF	<0.334	<0.430	0.636
2,3,4,7,8-PeCDF	<0.327	<0.420	0.771
1,2,3,4,7,8-HcXDF	<0.548	<0.480	0.585
1,2,3,4,6,7,8-HpCDF	<0.831	<0.748	0.871
Total PCDDs/PCDFs (homolog sum) (pg/g)	<0.327	<0.420	10.1

Notes:
mg/kg = Milligram per kilogram
pg/kg = Picogram per kilogram
PCDDs/PCDFs - Polychlorinated dibenzodioxins/Polychlorinated dibenzofurans
PCDD/PCDF congeners less than detection limits in all samples are not included in this table. For a complete list of these analytes, see Appendix A.
Samples were not analyzed for PCBs, SVOCs or VOCs.

TABLE 4-12
GLASS AGGREGATE PRODUCT ASTM LEACHATE SAMPLE RESULTS

Analyte	Sample Identification					
PCBs (Method 1668) (pg/g)	M-G-01	M-G-02	M-G-03	M-G-04	M-G-05	M-G-06
Total PCBs (homolog sum) (pg/g)	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500
Metals (mg/L)						
Arsenic	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Barium	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Cadmium	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Chromium	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Mercury	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
Lead	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Selenium	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Silver	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01

Notes:

pg/g = Picogram per gram
mg/L = Milligram per liter
PCBs = Polychlorinated biphenyls
PCB congeners less than detection limits in all samples are not included in this table. For a complete list of these analytes, see Appendix A.
Samples were not analyzed for PCDDs/PCDFs, SVOCs or VOCs.

Portions of the glass aggregate product were crushed and screened through a 200-mesh (75-micron, 0.003-inch) sieve at the University of Wisconsin at Platteville Engineering Department laboratory. Glass aggregate product samples had to be air-dried before crushing, so they were laid out in disposable aluminum pans in front of fans. Some of the pans were placed in drying ovens and set on circulating air only. After drying, the glass aggregate product was transferred to a rotating drum crusher that contained several steel balls of various sizes. The drum crusher (Soiltest Model M-501) was cleaned between each sample, and a sand blank was crushed and collected before each sample was placed in the crusher. The crushed glass was then transferred to sieves and shaken to separate the finely ground glass particles. Fine particles that passed the 200-mesh sieve were collected, extracted by SPLP methods, and analyzed for PCBs, metals, and SVOCs.

4.3.2.9.1 Glass Aggregate Product ASTM Water-Leach Test

Portions of the glass aggregate product samples collected from the six sampling runs were extracted by the ASTM water-leaching procedure (ASTM 1999) before analysis for PCBs and metals. Results of the extract analysis were used in the evaluation of Primary Objective P2 to determine the material's potential for beneficial reuse.

PCBs

PCBs were analyzed by high-resolution EPA Method 1668 (EPA 1997), and individual congeners and total PCBs were reported by the laboratory. Results of the ASTM extraction and PCB analyses are summarized in Table 4-12. The table shows that there were no detections of PCBs in any of the six sampling runs.

Metals

Glass aggregate product ASTM water leach samples were analyzed for RCRA metals by EPA Methods 6010B/7470A (EPA 1996). Individual metals analyzed and their resulting concentrations observed in glass aggregate leachates are detailed in Table 4-12.

Metals concentrations in ASTM-leachate samples are below detections limits for all metals analyzed.

4.3.2.9.2 Glass Aggregate Product SPLP Leach Test

Glass aggregate product composite samples also were extracted using SPLP (EPA 1996) and analyzed for PCBs, metals, dioxins and furans, and SVOCs. SPLP was designed to mimic rainwater leaching contaminants from a material and potentially migrating into groundwater. SPLP generally is used to more closely simulate actual rainwater leaching effects, rather than landfill leaching effects. The sample extract was analyzed for PCBs, metals, and dioxins and furans.

PCBs

After SPLP extraction, PCBs were analyzed by high resolution EPA Method 1668 (EPA 1997), with total PCBs and individual congeners reported by the laboratory. Results of the laboratory analysis are detailed in Table 4-13.

Results of the PCB analysis exhibited no detections of PCB congeners in any of the glass aggregate product samples.

Metals

Glass aggregate product SPLP leachate samples were analyzed for RCRA metals by EPA Methods 6010B/7470A (EPA 1996). Individual metals analyzed and their resulting concentrations observed in the glass aggregate product leachates are summarized in Table 4-13

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No detections of any of the metals analyzed were exhibited in any of the glass aggregate product sample leachates.

Dioxins and Furans

Glass aggregate product SPLP-leachate samples were analyzed for dioxins and furans by EPA Method 8290 (EPA 1996), and the laboratory provided results for individual compounds and total dioxins and furans. Results of the dioxins and furans analysis are summarized in Table 4-13.

As shown, the leachate was observed to contain total dioxins and furans concentrations ranging from 0.0332 to 0.615 ng/L (3.33×10^{-8} to 6.15×10^{-7} ppm).

TABLE 4-13
GLASS AGGREGATE PRODUCT SPLP LEACHATE SAMPLE RESULTS

Analyte	Sample Identification					
PCBs (Method 1668) (pg/g)	M-G-01	M-G-02	M-G-03	M-G-04	M-G-05	M-G-06
Total PCBs (homolog sum) (pg/g)	<0.562	<0.588	<0.61	<0.633	<0.725	<0.694
Metals (mg/L)						
Arsenic	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Barium	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Cadmium	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Chromium	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Mercury	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
Lead	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Selenium	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Silver	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
PCDDs/PCDFs (Method 8290) (pg/g)						
OCDD	0.387	<0.0445	<0.0377	<0.0323	<0.0261	<0.0310
1,2,3,4,6,7,8-HpCDF	0.0061	<0.0025	<0.0030	<0.0027	<0.0024	<0.0023
Total PCDD/Fs (homolog sum)	0.596	0.0615	0.0532	0.0385	0.0332	0.0435

Notes:

pg/g = Picogram per gram
mg/L = Milligram per liter
PCBs = Polychlorinated biphenyls
PCDDs/PCDFs = Polychlorinated dibenzodioxins/Polychlorinated dibenzofurans
-- Not sampled
PCB and PCDD/PCDF congeners, and SVOCs less than detection limits in all samples are not included in this table. For a complete list of these analytes, see Appendix A.
Samples were not analyzed for VOCs.

SVOCs

Four of the six glass aggregate product composite samples were submitted for SPLP extraction and SVOC analysis by EPA Method 8270C (EPA 1996). Total SVOC concentrations in SPLP-leachate samples are below detections limits for all SVOCs analyzed.

4.3.2.9.3 Crushed Glass Aggregate Product SPLP-Leach Test

Portions of the glass aggregate product composite samples were crushed and screened through a 200-mesh (75-micron, 0.003-inch) sieve. The crushed glass aggregate product was then transferred to sieves and shaken to separate the finely ground glass particles. The fine particles that passed the 200-mesh sieve were collected and submitted to a laboratory for SPLP extraction and analysis of PCBs, metals, and SVOCs.

PCBs

After the crushed glass aggregate product was subjected to SPLP extraction, PCBs were analyzed by high-resolution EPA Method 1668, with total PCBs and individual congeners reported by the laboratory. Results of the laboratory analysis are detailed in Table 4-14.

Results of the PCB analysis exhibited no detections of PCBs in any of the glass aggregate product composite samples.

Metals

Crushed glass aggregate product SPLP-leachate samples were analyzed for RCRA metals by EPA Methods 6010B/7470A (EPA 1996). Individual metals analyzed and their resulting concentrations observed in glass aggregate leachates are detailed in Table 4-14.

No metals were detected in any of the glass aggregate product composite sample leachates.

TABLE 4-14
CRUSHED GLASS AGGREGATE SPLP LEACHATE SAMPLE RESULTS

Analyte	Sample Identification					
PCBs (Method 1668) (pg/g)	M-CG-01	M-CG-02	M-CG-03	M-CG-04	M-CG-05	M-CG-06
Total PCBs (homolog sum) (pg/g)	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500
Metals (mg/L)						
Arsenic	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Barium	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Cadmium	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Chromium	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Mercury	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
Lead	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Selenium	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Silver	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
SVOCs (µg/L)						
Bis(2-ethylhexyl)phthalate	<5.0	--	<5.0	<5.0	--	14 J
Total SVOCs	<5.0	--	<5.0	<5.0	--	14 J

Notes:

pg/g = Picogram per gram
mg/L = Milligram per liter
µg/L = Microgram per liter
PCBs = Polychlorinated biphenyls
SVOCs = Semivolatile organic compounds
J = Estimated Value, Concentration Below Lower Calibration Range.
-- Not sampled
PCB congeners and SVOCs less than detection limits in all samples are not included in this table. For a complete list of these analytes, see Appendix A.
Samples were not analyzed for PCDDs/PCDFs or VOCs.

SVOCs

Glass aggregate product SPLP-leachate samples were analyzed for SVOCs by EPA Method 8270C (EPA 1996). The resulting concentrations expressed as total SVOCs observed in the glass aggregate product leachates are summarized in Table 4-14.

Only one SVOC (bis[2-ethylhexyl]phthalate) was detected in one of the four SPLP-leachate crushed glass aggregate product samples (M-CG-06). SVOC concentrations in SPLP-leachate samples were below detections limits for the other three crushed glass aggregate product samples analyzed.

4.3.3 SITE Demonstration Objectives

The main component of the Minergy GFT is an oxygen/fuel-fired melter that operates at a temperature of 1,600 °C (2,900 °F). The technology can be used to vitrify PCB-contaminated sediments as well as sediments containing metal contamination. When the molten glass is cooled, a glass aggregate is formed. The product has potential economic value as a concrete aggregate, roadbed fill, or other construction material.

The purpose of the SITE demonstration of the Minergy GFT technology was to provide an unbiased, quantitative evaluation of the effectiveness and cost of this technology. To ensure the collection of data that would allow such an evaluation, specific, performance-based objectives were developed. The two primary objectives are considered to be critical for the technology evaluation. Secondary objectives provide additional information that is useful but not critical. The following sections provide an evaluation of the primary and secondary objectives.

4.3.3.1 Primary Objectives Evaluation

The following primary objectives (P) are considered to be critical to the success of the SITE evaluation. For each objective, a brief description of the experimental approach is given.

P1 Determine the treatment efficiency (TE) of PCBs in dredged-and-dewatered river sediment when processed in the Minergy GFT.

The concentration of PCBs in river sediment, the glass aggregate product and all the waste streams were analyzed. The TE calculation for the GFT consisted of a comparison of the PCB content of the six composite samples of the dredged-and-dewatered sediment versus PCB concentrations of all other process outputs, including six composite samples of the glass aggregate product, quench water, and three

composite samples of the cooling-tower discharge. Based on the sampling methodology, the six flue-gas samples were discrete samples, not composite samples.

The TE of the GFT process was calculated as follows:

$$TE = (W_{in} - W_{out}) / W_{in} \times 100\%$$

Where:

W_{in} = Geometric mean of PCB input concentration:
For the GFT process, W_{in} represents the PCB concentration of the dredged-and-dewatered sediment; for the melting system only, W_{in} represents the PCB concentration of the drum-dried sediment.

W_{out} = Geometric mean of PCB output concentration:
For the GFT process, W_{out} represents the combined PCB concentrations of the process flue gas stream, the quench water stream, and the glass aggregate product.

A TE for the Holoflite® dryer demonstration could not be calculated due to the sediment carry-over into all waste streams and data incompatibility. Data collected during the Holoflite® dryer test were not used to determine a TE for the GFT because of the incompatibility of the PCB congener lists analyzed for the dryer and melter evaluations. The TE for the GFT was calculated using data obtained from sampling dredged-and-dewatered sediment from roll-off boxes. This calculation provides a TE for the technology as demonstrated by Minergy. Table 4-13 provides the geometric means of the input and output PCB data. The TE for the GFT process was calculated to be 99.9995 percent.[1]

A removal efficiency (RE) was calculated for the melter phase only of the GFT, because of the uncertainties associated with the drum dryer used to dry the bulk of the demonstration sediment. Only sediment entering and exiting the drum dryer were sampled, and samples of dryer exhaust gas or condensate were not collectable based on the dryer setup.

Minergy claims that commercial GFT units will condense all water vapor from the dryer vent and send it to the dredging wastewater treatment operation while non-condensable gases will be recycled to the melter.

The melter RE consisted of a comparison of six composite samples of dried and prepared sediment entering the furnace versus PCB concentrations of all other furnace outputs, including composite samples of glass aggregate, quench water, furnace flue gas, and cooling tower discharge water. The RE

[1] The treatment efficiency was calculated two ways: ND = MDL, the TE = 99.9994%; for ND = ½ MDL, the TE = 99.9995%.

calculation provides a measure of the efficiency of the melter furnace only. Minergy proposes that the final design of a full-scale GFT system will route all dryer output streams into the melter furnace. The RE for the melter phase only of the GFT was calculated to be 99.9995 percent.

P2 Determine whether the GFT glass aggregate product meets the criteria for beneficial reuse under relevant federal and state regulations. The aggregate product will be judged to be beneficial with respect to each metal or PCB if the 95 percent upper confidence limit (UCL_{95}) for the estimated mean (of each metal or PCB) is less than federal or state regulatory requirements, as applicable.

The final glass aggregate product from the GFT demonstration was subjected to SPLP and ASTM extractions. Aqueous extraction procedures were followed by analysis of the extracts for metals and PCBs. The results of these tests were evaluated against federal and state requirements to determine if the glass aggregate product is suitable for beneficial reuse. No federal criteria were found for evaluation of the glass material for beneficial reuse; however, the state of Wisconsin has promulgated a regulation with criteria for the use of industrial by-products. Results of the analyses on the extracts, as well as total contaminants in the glass aggregate product, were evaluated against Wisconsin Administrative Code Chapters NR 538 (NR 538) and NR140 (NR140) criteria. (WDNR 1997).

The purpose of Wisconsin's NR 538 regulation (WDNR 1997) is to allow and encourage the beneficial reuse of industrial by-products to preserve resources, conserve energy, and reduce or eliminate the need to dispose of industrial by-products in landfills. The regulation contains criteria for five categories of industrial by-products, the uses for which depend upon which criteria category the material meets. The categories dictate how the material can be used and become more restrictive as the criteria become less strict. The extent of allowable uses for the evaluated material (glass aggregate product) diminishes as the category numbers rise from one to five. Based on a chemical analysis of the glass aggregate product compared to the criteria in NR 538, the glass aggregate product qualifies for beneficial reuse under NR 538 Category 2 criteria. Under this category, the glass aggregate product qualifies for beneficial reuse as any of those products or uses described in the rule as Category 2 and may be subject to notification requirements.

TABLE 4-15
INPUT AND OUTPUT PCB CONCENTRATIONS

Feed or Waste Stream	Geometric Mean of Total PCBs in Samples (parts per million)
Dredged-and-Dewatered Sediment	28.8
Drum-Dried Sediment	22.4
Sediment Entering Melter	27.8
Glass Aggregate Product	1.37×10^{-4}
Flue Gas	3.51×10^{-6}
Quench Water	4.16×10^{-7}
Cooling-Tower Discharge Water	1.26×10^{-6}

Notes: When calculating the geometric mean non-detects were assigned a value of ½ the method detection limit.

Geometric Mean is calculated as $GM_y = \sqrt[n]{y1, y2, y3..yn}$

Material evaluation under Category 1 criteria is subject to strict standards, some of which are lower than current method detection limits. Category 2 criteria, while less stringent, still require low contaminant concentrations derived from total solid and ASTM water-leach analyses. Materials qualifying for beneficial reuse under Category 2 criteria are subject to monitoring and to regulatory and property owner notification requirements. A copy of Chapter NR 538 Wisconsin Administrative Code is provided in Appendix D.

Table 4-14 presents the post-demonstration glass aggregate product sample results compared to the NR 538 Category 2 criteria for both water-leach tests (SPLP and ASTM), for Total Elements Analysis (WDNR 1997), and for NR140 groundwater quality criteria (WDNR 2001). EPA's evaluation of the GFT product included water leach tests of the glass aggregate product, as well as the crushed glass aggregate product that passed through a 200-mesh (75-micron, 0.003-inch) sieve.

TABLE 4-16
BENEFICIAL REUSE RESULTS AND CRITERIA

Contaminant	Glass Aggregate Product ASTM[a] Leachate Concentration (mg/L)[b]	NR 538/NR140[c] Category 2 Criteria for Water Leach Tests (mg/L)	Total Elements Analysis Results for Glass Aggregate (mg/kg)[d]	NR 538 Category 2 Criteria for Total Elements Analysis (mg/kg)	Glass Aggregate Product SPLP[e] Leachate Concentration (mg/L)
Total PCBs [f]	$<5.00 \times 10^{-7}$	0.000003 [g]	0.00092	- [h]	$<6.35 \times 10^{-7}$
Arsenic	<0.10 [i]	0.05	5.1	21	<0.10
Barium	<0.010	4.0	341	-	<0.010
Cadmium	<0.010	0.005	0.51	-	<0.010
Chromium	<0.020	0.10	52	-	<0.020
Lead	<0.10	0.015	16	-	<0.10
Mercury	<0.00020	0.002	0.26	-	<0.00020
Selenium	<0.10	0.10	8.9	-	<0.10
Silver	<0.010	0.10	3.2		<0.010

Note:
a ASTM = American Society for Testing and Materials
b mg/L = Milligram per liter
c NR538/NR140 = Wisconsin Administrative Code Chapters NR 538 and NR 140
d mg/kg = Milligram per kilogram
The Total Elements Analysis Results for Glass Aggregate are derived from the glass-aggregate-composite-sample results. These values are the 95% upper confidence bound (UCB) of the arithmetic mean of the glass aggregate results. The 95% UCBs for arsenic, cadmium, and mercury are calculated from method detection limits. The methods used for the calculation of the 95 % UCB are detailed in the QAPP Section 3.2.
e SPLP = Synthetic Precipitate Leaching Procedure. SPLP analysis results are not compared to NR 538 Category 2 criteria.
f PCBs = Polychlorinated biphenyls
g NR 538 does not contain criteria for total PCBs. The criteria for comparison is NR 140, Groundwater Quality Standards Preventive Action Limit
h - Criteria do not exist
i < less than

As shown in Table 4-14, the glass aggregate product meets the Wisconsin NR 538 beneficial reuse criteria for Category 2 with the possible exception of arsenic and cadmium. The NR 538 water leachate criteria for arsenic and cadmium are lower than the detection limits for each of these elements.

4.3.3.2 Secondary Objectives Evaluation

The following secondary objectives are not considered critical to the success of the evaluation but may offer additional information on the innovative technology. For each objective, a brief description of the experimental approach is given.

S1 Determine the unit cost of operating the GFT on dredged-and-dewatered river sediment.

The unit cost of removing PCBs and organic and inorganic contaminants from river sediment were determined based on data provided by Minergy. This secondary objective was achieved by assessing twelve expense categories.

Capital and operating costs were estimated for conducting a full-scale operation of the GFT. A detailed discussion of costs is included in Section 3.0 of this report. The NPV of the facility described in this document was estimated at $122,041,000. The estimated cost per ton to treat the sediments is $38.74 per ton.

S2 Quantify the organic and inorganic contaminant losses from the existing or alternative drying process used to dry the dredged-and-dewatered river sediment.

The sampling plan for the dryer demonstration was designed to permit the quantification of organic and inorganic content before and after the drying process. However, the small scale of the demonstration and the carryover of dust from the dryer into the condensate and gas streams gave rise to ambiguous results. As explained in Section 4.2.1.1, the Holoflite® dryer process evaluation had critical flaws, which prevented proper evaluation of contaminant losses. The results of the PCB analyses were based on a limited list of congeners and are not comparable to PCB analyses performed after the dryer demonstration. The list of congeners was based on a small number of congeners (about 25) that were considered to be among the most toxic PCB constituents, but these congeners were not necessarily present in the PCBs used by the paper industry or found in the sediment used in the GFT demonstration. The evaluation of the Secondary Objective S2 was not completed because of these differences. Analytical results of samples collected during the Holoflite® dryer demonstration are presented in Appendix C.

Also, because the carryover of dust into the condensate and dryer gas streams resulted in suspect results, inorganic contaminant losses were not characterized for the dryer.

S3 Characterize the organic and inorganic constituents in all GFT process input and output streams.

Secondary Objective S3 was intended to combine data from all the input and output streams of the GFT process and characterizes the results. As noted in Section 1.0, the GFT process consists of a drying phase and a melting phase. Input streams include: dredged-and-dewatered sediment, dried sediment, flux, and city water. Output streams include: dried sediment, dryer gas, dryer condensate, glass aggregate, furnace gas, quench tank water, cooling tower discharge water, and accumulated dust. These input and output streams were analyzed for some or all of the following analytes: PCBs, dioxins and furans, metals, SVOCs, VOCs, and HCl/Cl_2. VOC analysis was conducted on both pre- and post- melter samples to evaluate the potential production of VOCs in the melting process.

Analytical results of the samples collected from all input and output streams, which were presented in Section 4.3 through 4.3.2.8, were evaluated for this objective. This objective consisted mainly of review and presentation of analytical results from the demonstration, and not an interpretation. Analytical results from the melter demonstration were presented in Tables 4-2 through 4-12, while Holoflite® dryer demonstration results are presented in Appendix C.

As in Secondary Objective S2, Analytical results of all of the samples collected during both the pilot-scale dryer test and the melter test were evaluated in a similar manner as those used to obtain Primary Objective P1. The UCL_{95} were calculated with the same formula described in Primary Objective P2. This objective consisted mainly of a review of analytical results from the demonstration and not an interpretation.

Results of the Holoflite® dryer test are presented in Appendix C. Analytical results of dredged-and-dewatered sediment samples collected from the roll-off boxes and drum-dried sediment samples collected from the supersacks at the Minergy facility in Winneconne, Wisconsin, were detailed previously in Tables 4-2 and 4-3, respectively.

Melter samples were collected during the demonstration in August 2001, results of which were presented in Section 4.3.2.

4.4 DATA QUALITY

Data and analytical results from 94 percent (191 samples) of the 203 samples analyzed in support of the GFT demonstration were reviewed for quality, usability, and evaluation of the primary objectives. Data validation was performed on PCBs, metals, dioxins and furans, SVOCs, VOCs, and hydrogen chloride/chlorine results. This validation was based on a review of the QC results, which included surrogate recoveries; laboratory control samples (LCS) and laboratory control sample duplicates (LCSD); matrix spikes (MS) and matrix spike duplicates (MSD); and field, equipment, and method blanks. The following paragraphs briefly summarize the results of the QC analyses; more detailed information is provided in the TER.

4.4.1 Surrogate Recoveries

Surrogates are compounds of known concentrations added to each sample to evaluate the effectiveness of the analysis in measuring organic contaminants that may be present in the sample. The analytical results of surrogate compounds in samples analyzed by the laboratories were found to be within acceptable limits, except in the samples described below.

Most of the problems with surrogate recoveries were observed in the SVOC analyses. Several samples had low or no surrogate recoveries, indicating a possible low bias for associated sample results. The acid surrogate 2,4,6-tribromophenol was not recovered in any of the dried melter feed samples (M-S-01, -02, -03, -04, and -03D). Additionally, the recoveries for two other acid surrogates, 2-fluorophenol and phenol-d5, were low for samples M-S-03, M-S-03D, and M-S-04. All phenol results for the dried melter feed samples were nondetect but were qualified as invalid (IS) because of poor surrogate recoveries. Therefore, the SVOC results for these samples were qualified as IS. The percent recoveries of all SVOC analytes in the MS and MSD sample (M-G-03), which was designated as the soil MD/MSD sample, were within QC limits with the exception of N-nitrosodimethylamine for which the recovery was below the lower QC limit of 40 percent. The non-detect result for this analyte has been qualified as estimated nondetect (UJ), because of the likely low bias. Although there could have been a negative bias in the phenol and single N-nitrosodimethylamine results, when calculating total SVOCs in these samples, all these results were assumed to be below their detection limits. Discrepancies were observed for the SVOC duplicate analysis on sample M-S-03. The results for the analysis of the primary sample showed the presence of seven polynuclear aromatic hydrocarbons (PAHs), ranging in concentration from 190 ug/kg for benzo(k)fluoranthene to 340 ug/kg for benzo(b)fluoranthene. The results for all these PAHs were

reported as nondetect for the analysis of the duplicate sample M-S-03D. The discrepancy reflects, most likely, nonhomogeneous sample matrix. The concentrations of the 7 PAHs reported in sample M-S-03, therefore, are qualified as estimated values based on the uncertainty of the overall precision of sampling and analytical procedures.

Some minor problems, such as low recoveries and out of calibration range results, were observed with surrogate recoveries in VOC analyses that did not warrant qualifications. For samples M-S-03, M-S-04, and M-S-04D the recovery of VOC surrogate dibromofluoromethane, at less than 10 percent for each sample, was unacceptable. In addition, for sample M-S-04D, the recoveries of 1,2-dichloroethane and 4-bromofluorobenzene were marginally biased high. No data, however, were impacted for samples M-S-03 and M-S-03D for VOC analysis, because out-of-control recovery of one surrogate is acceptable. For sample M-S-04D, all analytes associated with these two surrogates were nondetect in the sample. No data, therefore, were qualified based on the high recoveries of the two surrogates.

4.4.2 Laboratory Control Sample/Laboratory Control Sample Duplicate

An LCS is a blank sample consisting of laboratory-grade water with method-appropriate reagents, spiked with known concentrations of target analytes and analyzed in exactly the same way as field samples. Recovered concentrations of spiked analytes are then determined as percent recoveries (%R), which are used to evaluate the precision and accuracy of the analytical procedure.

Recoveries for LCSs and LCSDs analyzed for SVOCs were within QC limits, with the following exceptions. Two compounds were found to be out of control limits, and their associated non-detect (ND) results were qualified as estimated (UJ). The non-detect results for 4,6-dinitro-2-methylphenol, 2,4-dinitrophenol, and pentachlorophenol were qualified as invalid (IV) for both flue gas samples because of the possible extremely low bias in their recoveries during analysis, and these samples are not included in the ITER. It is important to note that SVOCs are reported as total SVOCs in the ITER.

In general, LCSs and LCSDs analyzed for metals were within laboratory control limits, and no data were qualified as a result. Dioxins and furans control samples were analyzed within limits.

4.4.3 Matrix Spike/Matrix Spike Duplicate

MS/MSDs are field samples that are used to determine the effect the sample matrix has on the analysis of the samples. In an MS/MSD, the sample matrix is (1) identical to those submitted as samples, (2) spiked with known concentrations of target analytes, and (3) analyzed in exactly the same way as the other samples. One pair of MS/MSD samples was submitted to the laboratories for each group of samples (sediment, glass, quench water) and for each analysis requested (PCBs, dioxins and furans, VOCs, and SVOCs). The recoveries of all the MS/MSDs were in control, with the following exceptions.
In the MS/MSD samples analyzed, three compounds were detected outside of established laboratory control limits. As a result, these detected compounds, which were not detected in the field samples, were qualified as estimated (UJ).

In one MS, 28 of 70 VOCs were detected below QC limits. For these compounds, any NDs in corresponding samples were qualified as estimated (UJ) and any detections were qualified as estimated (J).

4.4.4 Equipment Blanks, Field Blanks, and Method Blanks

Six equipment blanks and 11 field blanks, were collected during the GFT demonstration. PCBs were detected at low levels – less than 1 nanogram per liter in two of the field blank samples and less than 40 pg/g in two sand field blank samples. However, the congeners were not detected in samples associated with the field blank samples, and qualification of sample results was not warranted.

One sand field blank was collected and submitted to a laboratory for SVOC analysis. No SVOCs were detected at concentrations above method detection limits, and no qualification of samples associated with the sand blank was warranted.

None of the equipment and field blank samples was analyzed for dioxins and furans or metals.
Ten method blanks were analyzed by the laboratory as well as two trip blanks for VOC analysis.

4.4.5 Audits

As a vital part of the QA program, one field audit and one laboratory audit were conducted by EPA to ensure that measurements associated with sampling and analysis were in conformance with the final QAPP (EPA 2001). The audit of field activities was conducted on June 21, 2001. Two findings and four

minor observations were documented. The first finding recommended collection of field blanks in the sample preparation area to document any potential impacts that fugitive dust might have on sediment and glass aggregate product samples. The second finding recommended the collection of sand blanks between crushed glass aggregate samples. Both of the recommendations were agreed upon and implemented. All of the minor observations were also agreed to and implemented.

The Paradigm Analytical Laboratory audit was conducted on March 21, 2001. Two observations were noted by the auditors. Paradigm addressed the observations, and data quality was not affected. The TER documents the results of these audits.

4.4.6 QAPP Sampling Deviations

For various reasons the number of samples specified in the QAPP were not collected. Table 4-17 list the planned sampling protocol, the actual samples collected, and the rationale for any changes in the QAPP.

4.5 OVERALL EVALUATION

Evaluation of the analytical data indicates that the GFT was able to significantly reduce PCB contamination in all samples collected. The GFT successfully destroyed 99.9995 percent of the total PCBs in the river sediment. The glass aggregate produced by Minergy's GFT met Wisconsin Administrative Code Chapter NR 538 Category 2 criteria and qualified for beneficial reuse under the regulation. This qualification allows a wide range of uses, including as an additive to concrete, a material in floor tiles, and as construction fill. It also requires environmental monitoring and regulatory notification under the accepted uses.

The GFT reduced the concentration of dioxins and furans in the dried sediment. Total dioxin and furan concentrations in the glass aggregate ranged from 1.77 to 3.77 pg/g, a reduction of greater than 99 percent.

The GFT appeared to be capable of decreasing mercury concentrations in the river sediment. Mercury was observed in sediment at a concentration slightly less than 1 part per million, and it was not detected in the glass aggregate analysis. If not removed by the furnace thermally, the mercury likely was inactivated within the glass matrix. Furnace flue gas samples did not detect mercury above method detection limits. Nor did mercury leach from the glass aggregate, as evidenced by the results of the American Society of Testing and Materials (ASTM) and Synthetic Precipitate Leaching Procedure

(SPLP) water leach tests.

Analysis of the sediment, glass aggregate product, and other output streams indicate that SVOCs and VOCs were not contaminants of any measure, and treatment of the sediment by the GFT did not create byproducts in the process waste streams. Similarly, dioxins and furans were observed at only minor concentrations in the glass aggregate product samples. The destruction of PCBs in the sediment did not cause hazardous constituents in the furnace flue gas to be released during operation.

Based on information from Minergy and observations made during the SITE evaluation, the estimated treatment cost is $38.74 per ton of dredged-and-dewatered sediment containing 50 percent moisture. Unit costs may depend on the location of the treatment facility, sediment moisture, and potential product end use. Sale of the glass aggregate product would decrease the costs of treatment, but SITE's determination of process cost per ton of material did not take into account the sale of the glass aggregate.

TABLE 4-17

DISCREPANCIES TO QAPP SAMPLE PROTOCOL FOR MINERGY MELTING DEMONSTRATION

DESCRIPTION AND PURPOSE	SAMPLE TYPE	ANALYSES SPECIFIED IN QAPP			ACTUAL ANALYSES			RATIONALE FOR DIFFERENCE
		NUMBER OF SAMPLES PER COMPOSITE	PARAMETER	NUMBER OF SAMPLES	NUMBER OF SAMPLES PER COMPOSITE	PARAMETER	NUMBER OF SAMPLES	
Dredged-and-dewatered sediment collected from roll-off boxes	Composite	-	-	-	5	PCB	6	Needed to collect samples of the wet sediment for calculation of the treatment efficiency
Dried, mixed sediment without flux addition To determine the variability of the material Collected from Supersacks	Composite	28	PCB	6	42	PCB	6	It was determined that three samples from each of 14 sacks should be split three ways to represent all sacks associated with each roll-off box above.
Dried, mixed sediment with flux addition To determine the chemical characteristics of the dried sediments prior to the melter Collected over 6-hour periods	Composite	24	PCB	6	24	PCB	6	Samples were collected at 15-minute intervals over 6-hour periods. Two additional dioxin/furan analyses were performed to better characterize the sediment entering the melter
	Composite	24	Dioxin/Furan	4	24	Dioxin/Furan	6	
	Composite	24	SVOC	4	24	SVOC	4	
	Composite	24	Metals	4	24	Metals	6	
	Composite	24	Mercury	6	24	Mercury	6	
	Composite	24	VOC	4	24	VOC	4	
Glass material from the melter To determine the chemical characteristics of the glass Collected over 6-hour periods	Composite	24	PCB	6	24	PCB	6	Samples were collected to match those collected of the sediment entering the melter. One VOC analysis was added to confirm the absence of VOCs in the glass
	Composite	24	Dioxin/Furan	4	24	Dioxin/Furan	4	
	Composite	24	SVOC	4	24	SVOC	4	
	Composite	24	Metals	4	24	Metals	6	
	Composite	24	Mercury	6	24	Mercury	6	
	Composite	-	VOC	-	24	VOC	1	

DESCRIPTION AND PURPOSE	SAMPLE TYPE	ANALYSES SPECIFIED IN QAPP			ACTUAL ANALYSES			RATIONALE FOR DIFFERENCE
		NUMBER OF SAMPLES PER COMPOSITE	PARAMETER	NUMBER OF SAMPLES	NUMBER OF SAMPLES PER COMPOSITE	PARAMETER	NUMBER OF SAMPLES	
Glass material from the melter To determine the chemical characteristics of the leachate extracted off the glass surface Collected over 6-hour periods	Composite	24	PCB	6	24	PCB	12	PCB, metals, and mercury samples were analyzed with both ASTM and SPLP extractions, doubling the number of samples analyzed. Six, rather than 4, samples were analyzed for the full RCRA suite of metals because there was no difference in cost to analyze the suite and mercury only. Two additional dioxin/furan samples were analyzed because dioxins/furans were detected in pre-melter sediment
	Composite	24	Dioxin/Furan	4	24	Dioxin/Furan	6	
	Composite	24	SVOC	4	24	SVOC	4	
	Composite	24	Metals	4	24	Metals	12	
	Composite	24	Mercury	6	24	Mercury	12	
Glass material from the melter Crushed to <200 mesh To determine the chemical characteristics of the leachate extracted off the glass surface Collected over 6-hour periods	Composite	24	PCB	12	24	PCB	6	All crushed glass samples were analyzed with SPLP extractions only. Dioxin/furan analysis of crushed glass was not performed because this parameter was non-critical, the analyses were expensive, and analysis by ASTM and SPLP extractions had already been performed on the glass aggregate samples. It was expected that dioxins and furans, if present, would be adsorbed to the surface of the glass particles and crushing the glass would not cause a difference in concentration. Six samples were analyzed for the full RCRA suite of metals because there was no difference in cost to analyze the suite and mercury only.
	Composite	24	Dioxin/Furan	6	24	Dioxin/Furan	-	
	Composite	24	SVOC	4	24	SVOC	4	
	Composite	24	Metals	4	24	Metals	6	
	Composite	24	Mercury	6	24	Mercury	6	

DESCRIPTION AND PURPOSE	SAMPLE TYPE	ANALYSES SPECIFIED IN QAPP			ACTUAL ANALYSES			RATIONALE FOR DIFFERENCE
		NUMBER OF SAMPLES PER COMPOSITE	PARAMETER	NUMBER OF SAMPLES	NUMBER OF SAMPLES PER COMPOSITE	PARAMETER	NUMBER OF SAMPLES	
City Water To determine the quality of the water entering the quench tank Collected at the beginning and the end of the 6-day period	Grab	NA	PCB	2	NA	PCB	1	One sample of city water was collected during the melter demonstration to save costs.
	Grab	NA	SVOC	2	NA	SVOC	1	
	Grab	NA	Metals	2	NA	Metals	1	
Quench Water To determine the quality of the water exiting the quench tank Collected over 6-hour periods	Composite	12	PCB	6	12	PCB	6	Two additional samples were analyzed for metals to better characterize the quench water
	Composite	12	SVOC	4	12	SVOC	4	
	Composite	12	Metals	4	12	Metals	6	
Discharge from Cooling Tower To determine the quality of the water discharged Collected at the beginning and end of the 6-day period	Grab	NA	PCB	2	NA	PCB	3	Recirculating pump broke down after the first sample was collected, and the system was remodeled to use fresh water. Two samples (including both SVOC samples) were collected after the cooling tower was retrofitted.
	Grab	NA	SVOC	2	NA	SVOC	2	
	Grab	NA	Metals	2	NA	Metals	3	
Gas Sample Train 1 To determine the chemical characteristics of the materials discharged to the pollution control equipment Collected over 4 hours	Grab	NA	PCB	6	NA	PCB	6	No discrepancies
	Grab	NA	Dioxin/Furan	6	NA	Dioxin/Furan	6	
Gas Sample Train 2 To determine the chemical characteristics of the materials discharged to the pollution control equipment Collected over 4 hours	Grab	NA	SVOC	4	NA	SVOC	2	Samples for SVOC and VOC were reduced to conserve time during the demonstration. Due to plugging of the sample probe, sample collection for all samples took longer than planned.
	Grab	NA	Metals	4	NA	Metals	4	
	Grab	NA	HCl/Cl_2	4	NA	HCl/Cl_2	4	
Collected over 1 hour	Grab	NA	VOC	12	NA	VOC	2	

DESCRIPTION AND PURPOSE	SAMPLE TYPE	ANALYSES SPECIFIED IN QAPP			ACTUAL ANALYSES			RATIONALE FOR DIFFERENCE
		NUMBER OF SAMPLES PER COMPOSITE	PARAMETER	NUMBER OF SAMPLES	NUMBER OF SAMPLES PER COMPOSITE	PARAMETER	NUMBER OF SAMPLES	
Accumulated dust deposited in the flue gas-sampling probe	Composite	-	Dioxins/Furan	-	8	Dioxins/Furan	3	Dust material was collected each time the probe was extracted and cleaned out. The material was composited over the entire day. Dust accumulation was not foreseen before the demonstration began.
	Composite	-	Metals	-	8	Metals	3	
Gas Sample Train To determine the chemical characteristics of the materials discharged by the pollution control equipment Collected over 4 hours	Grab	NA	PCB	3	NA	PCB	3	No discrepancies
	Grab	NA	Dioxin/Furan	3	NA	Dioxin/Furan	3	
	Grab	NA	SVOC	3	NA	SVOC	3	
	Grab	NA	Metals	3	NA	Metals	3	
Sample of Flux Additive To validate chemical characteristics of any additives to the process Collected from single lot	Grab	NA	PCB	2	NA	PCB	1	One sample of flux material was adequate to characterize any additives to the process
	Grab	NA	Dioxin/Furan	2	NA	Dioxin/Furan	1	
	Grab	NA	SVOC	2	NA	SVOC	1	
	Grab	NA	Metals	2	NA	Metals	1	

Notes: For sampling locations, see QAPP Figure 4-2
- Sample not specified to be collected or analyzed
ASTM - American Society for Testing and Materials
SPLP - Synthetic Precipitate Leaching Procedure